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The Ecological Features of Certain Sheltered Intertidal Areas in Tasmania

By

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WITH 3 PLATES

(Read 15th September, 1952)

SUMMARY

The salient features of sheltered shores are described. Most of the areas visited lie on the shores of D'Entrecasteaux Channel but some of the places are in sheltered localities in other parts of southern Tasmania. The most striking feature of sheltered coasts is the very great poverty of the fauna and flora. This feature has been noted in connection with all the coasts of Tasmania but the sheltered shores are in some places literally devoid of macroscopic forms at levels higher than the *Galeolaria* beds. The most common algae are the *Cystophoras* but in many inlets the Infralittoral Fringe is occupied by *Zostera*. This is especially true of bays where a change in the nature of substratum occurs at the level of 'low low' tide. One interesting area in the southern part of D'Entrecasteaux Channel shows the typical zonation of a wave exposed coast. This very restricted area is exposed to the southerly swell.

INTRODUCTION

This paper is the fourth of a series describing the features of the intertidal ecology of Tasmania. The first three papers appeared in this journal and are listed in the references (Guiler, 1950 and 1951a-b).

Most of the areas examined lie on the shores of D'Entrecasteaux Channel which separates Bruny Island from the Mainland of Tasmania. The Channel is about 50 miles in length and most of this distance is sheltered from heavy seas. The southern end of the Channel is exposed to gales and heavy seas from the south.

The localities visited are mostly in the northern part of the Channel. The shore was examined at Kettering, Barnes Bay on Bruni Island, Kettering, Oyster Cove, Dover, Port Esperance, Snug and Tinderbox. A very brief examination was made at Catamaran.

The major survey was carried out in Barnes Bay but Oyster Cove and Kettering were also studied in some detail. Notes describing the salient ecological features of areas not in the Channel are included. These places are Dodge's Ferry and the Grange.

(a) The Barnes Bay Area

Barne's Bay lies on the western shore of Bruni Island. It is a large bay which is divided into several smaller areas of water. At the eastern end of the bay are two inlets which run parallel to the main direction of the Channel. These inlets are known as Simmonds Bay. All the Barnes Bay area is sheltered from wave action and the Simmonds Bay area must be among the most sheltered waters in Tasmania.

Several transects were examined but details are given of only one of these as there is a very great similarity throughout most of the shore of the bay.

TRANSECT 1

Station	On rocks at the southern side of the entrance to Simmonds Bay.
Dates	20th February, 1951 and several previous dates.
Type	Sheltered rocky coast.
Maximum wave exposure	s. (0-6). 1. b, 2.
Description	The transect lies on the gently sloping rocks on the shore a short distance from a small point at the entrance to Simmonds Bay. The rocks on this side of the entrance are gently sloping (southern side). A large dead tree lying at the edge of the water is 50 yards to the west of the transect.
Geology	Mudstone.
Tidal data	From the Hobart Recorder.
Physical Environment	As described for Blackman's Bay.
Zonation	The basic zonation is . . . .

Melaraphe unifasciata
Barnacle belt
Siphonaria diemenensis + *Austrocochlea obtusa, Galeolaria caespitosa, Hormosira banksii* + *Mytilus planulatus, Cystophora* sps.

The Supralittoral Zone

This zone is devoid of any macroscopic life, being composed of bare rock.

The Supralittoral Fringe

The only organisms found in this zone are the gastropod *Melaraphe unifasciata* and the crab *Cyclograpsus punctatus* (M-Ed.). The gastropod is relatively few in numbers and forms a belt only 4 inches in vertical height. This can be attributed to the lack of splash from the very slight wave action. The wave action in turn is controlled by the very narrow stretch of water over which the wind can blow waves on to the transect. A few hundred yards towards the Channel where the bay is wider the *Melaraphe* population becomes quite dense with up to 20 individuals per square foot. At this place the bay widens in a northerly direction and the prevalent wind blowing from that direction causes greater wave action and spray. It might be noted that the maximum wave action is not likely to be experienced very often at the transect as it could only be encountered when the wind was in a restricted north-westerly quarter. The most usual wave action is somewhere in the region of s. (1-5). 0. b,2. In places where there is little spray *Melaraphe* does not live on small stones but where there is some spray the species frequents almost any non-crytic habitat.

The crab *Cyclograpsus punctatus* is not found in places where there are no loose boulders. The crab hides under rocks and especially under places where there are stones piled on top of each other. It is very quick in its movements and difficult to catch in its favourite environment.

The Midlittoral Zone

The top belt in this zone is that inhabited by the barnacle *Elminius modestus* Darwin and *Chamaesipho columna* (Spengler). Of these two

species, *Elminius* is found slightly higher on the shore than *Chamaesipho*, but this difference may only be local in occurrence.

The barnacles do not form a continuous belt on the shore but are found in clusters on the rocks. Living in the barnacle belt are numerous individuals of the mollusc *Bembicium nanum*. On the transect this latter species does not form a band, but in places where there is a nearly horizontal substratum with small stones the gastropod is very plentiful, the zonation being as shown below.

Melaraphe unifasciata
Bembicium nanum
Barnacles.

It was noted at Blackman's Bay that *Bembicium nanum* does not tolerate wave action and from observations made on the shore in this area it appears that it does not live on steep slopes.

The barnacle belt is only two feet in vertical height. The lack of wave action and spray in this area is reflected in the narrow vertical height of the zones.

The barnacle belt is replaced by a mixed strip of *Siphonaria diemenensis* and *Austrocochlea obtusa* (Dillwyn). As the wave action increases the belt becomes dominated by *Austrocochlea obtusa*. Also found in this belt are a few *Cellana limbata, Patelloida alticostata* and *Patelloida cantharus*.

Austrocochlea obtusa does not inhabit vertical or steep rock faces, but it is very numerous on horizontal or nearly horizontal rocks to the west of the transect. The occurrence on these horizontal faces is not correlated with wave action. It is also extremely numerous on a stony horizontal shelf in the southern inlet of the bay.

The *Galeolaria* belt follows below the mixed *Siphonaria-Austrocochlea* belt, but the worm tubes do not form thick crusts on the rocks. However, they do form a very prominent band round most of the shore. *Galeolaria* occurs most plentifully in places where there is drainage of water off the rocks, e.g., in clefts in the rock along which water runs or between two rocks where waves pass.

Hormosira banksii is not common on the shore. In some places it dominates the mussels but in most parts of the shore the alga is present as a sub-dominant. At places where the wave action reaches a maximum the *Mytilus-Hormosira* zones are raised up on the shore and *Brachyodontes rostratus* (Dunker) occurs as a thin belt above them. Several *Modiolus pulex* Lam. are to be noted at this same place. The zoning here is as listed below.

Melaraphe unifasciata
Bembicium nanum
Barnacles
Austrocochlea obtusa
Galeolaria caespitosa
Brachyodontes rostratus
Mytilus planulatus
Cystophora sps.

The Infralittoral Fringe

The Infralittoral Fringe is dominated by *Cystophora cephalornithos* (Lab.) J. Ag. and *Cystophora torulosa* (R.Br.) J. Ag. Other species

found in the Infralittoral fringe are *Ecklonia radiata* (Ag.) J. Ag., *Sargassum verruculosum* (Mert.) Ag. and *S. paradoxum* (R.Br.) Harv. These species form a forest on which many smaller species of algae are found.

About six feet below low water level the Infralittoral is populated by a dense growth of *Zostera nana*. The belt is not found over the whole of the bottom of the bay but is confined to the edges of the Infralittoral.

Comparison with Other Parts of the Bay

An interesting condition is to be seen on the western shore of the southern inlet at the head of Barnes Bay. This inlet is extremely sheltered and the wave action encountered is negligible. The shore is composed of muddy sand, at the upper end of which is a low bank of soil which supports a number of large trees. The shore has several dead trees as well as broken branches lying on it. The zonation here is most interesting as the mussel, *Mytilus planulatus* extends nearly up to the bank, living attached to the trees, &c. The mussels near the top of the shore experience nearly eighty to ninety per cent exposure but this does not appear to inconvenience them. They are smaller in size than those found in the lower Midlittoral. Above the *Mytilus planulatus* the smaller *Brachyodontes rostratus* forms a thin and not well defined band extending as far as the soil bank. Thus, in this region, we have the unique feature of most of the solid objects in the intertidal belt covered by mussels. The gastropod *Austrocochlea obtusa* is present in some numbers over most of the shore. The Infralittoral Fringe has clusters of *Mytilus planulatus, Pyura praeputialis* and *Ostraea*. These clusters extend for some distance across the lagoon bottom but in many places they are replaced by patches of *Cymodocea antarctica* or *Zostera nana*.

On the same shore as that described above at a small rocky point near a prominent sandy spit the zoning is as shown below.

Bare rock
Bembicium
Austrocochlea
Galeolaria + *Sypharochiton*
Mytilus + *Galeolaria*
Muddy bottom with *Alpheus*.

The shore slopes gently from the bottom of low cliffs of mudstone, the slope being 2½ feet in 22 feet.

The *Bembicium* belt is about 5 feet in width of which the last foot is mixed with *Elminius modestus*. The barnacles are not sufficiently numerous to form a belt.

The *Austrocochlea* belt is also 5 feet in width, of which the last 3 feet are mixed with *Siphonaria diemenensis*. There is no Patelloid belt as the *Austrocochlea* is replaced by *Galeolaria* + *Sypharochiton*.

Galeolaria occurs on stones and rocks and the chiton, *Sypharochiton pellis-serpentis* is very numerous in cracks between the rocks. Also found in this belt are *Austrocochlea obtusa, Siphonaria diemenensis* and *Patelloida alticostata*.

The lowest belt on the shore is occupied by mussels and *Galeolaria*. The serpulid is only common in the upper parts of the zone. The belt

is terminated by a muddy bottom on which there is no suitable substratum for the mussels to settle.

It is most noticeable that there is a very small number of species found on the shore. The algae are absent, even from the Infralittoral Fringe.

At a place where the cliffs shelter most of the shore the zoning is as below.

Bare rock
A narrow belt of *Elminius modestus*
Mussels and *Galeolaria*
Mussels and *Pyura*.

On the sun-exposed side of the inlet the mussels occur on only the sheltered sides of logs at or about mean sea level.

In this region it can be seen that the degree of sun exposure is an important factor controlling the distribution of the mussel *Mytilus planulatus*. The species is found farther up the shore on the sun-sheltered side of the southern inlet at the head of Barnes Bay.

(b) Kettering

The area examined at Kettering was chosen with a view to examining further the distribution of the mussels in relation to sun exposure. The part of the shore examined is at the point at the northern end of the bay. The shore in this area is sheltered from the sun by cliffs and trees.

TRANSECT 2

Station	On the point at the northern end of Little Oyster Cove, Kettering.
Date	12th April, 1950.
Type	Sheltered rocky coast.
Maximum wave action	s. (1-5). 2. b, 2.
Description	The transect runs vertical to the shore line just to the north of the point. Plate 49 is slightly oblique to the line of transect. There is a 2 feet high ledge at the top of the shore and below this the shore forms a platform which has a few loose rocks lying on it. The lower shore is composed of loose stones and rocks scattered on the mudstone platform. The distance from the top of the platform to the *Cystophora* is 37 feet with a drop of 3 feet.
Geology	Mudstone.
Tidal data	From the Hobart Recorder.
Physical Environment	As described for Blackman's Bay.
Zonation	*Mesembryanthemum aequilaterale*, *Brachyodontes rostratus*, *Austrocochlea* + *Mytilus*, *Galeolaria* + *Mytilus*, a mixed belt, and *Cystophora* sps.

The Supralittoral Zone

The Supralittoral is largely occupied by *Mesembryanthemum*. This succulent grows in the rock clefts below the *Casuarina* but it is very local in distribution. It is possible that the species is Terrestrial and not Supralittoral.

The Supralittoral Fringe

The gastropod *Melaraphe unifasciata* is very rare or absent over most of this part of the shore. On the line of section the species is absent. In other places it is present in cracks but even in this habitat it is scarce. On this part of the coast it is certainly true to say that the *Melaraphe* belt does not exist.

The Midlittoral Zone

At the foot of the ledge the small mussel, *Brachyodontes rostratus* is plentiful in cracks. The surface of the platform is bare. The *Brachyodontes* belt is narrow but forms a well defined band round all of the shore. A few *Elminius modestus* and *Chamaesipho columna* are to be found in sun sheltered places but they do not form a characteristic strip.

The *Brachyodontes* belt is replaced by one of gastropods and mussels. The species are *Austrocochlea* and *Mytilus planulatus*. The gastropod roams over the surface of the platform but the mussel is confined to cracks. In the lower part of the belt the mussels are also found on the surface of the rocks. In the upper part, *Patelloida conoidea* is the only other large organism found in the cracks.

Sypharochiton pellis-serpentis, Patelloida conoidea and *P. alticostata* live in cracks just above the *Galeolaria* band in the lower part of the exposed platform.

The mussels form small clusters in places and *Cominella lineolata, Lasaea australis, Paragrapsus gaimardii* and *Petrolisthes* sp. live among the byssus strands.

Galeolaria appears at about a distance of 16 feet from the top of the platform but does not form a belt until about 19 feet from the edge. The serpulid forms a discontinuous, but very prominent, band along the shore especially on the loose stones at the lower end of the platform. The presence of this species on loose stones is a significant indication of the lack of strong wave action (Plate 1).

Also found in the *Galeolaria* belt are *Mytilus planulatus, Siphonaria diemenensis, Sypharochiton pellis-serpentis* and *Patelloida alticostata.*

At a distance of 24 feet from the top of the section is a large boulder (at the left-hand side of Plate 1). The boulder is largely populated by serpulids and *Mytilus* with the lichen *Lichina confinis* and some *Elminius* and *Chthamalus.* On the sun sheltered side *Ulva lactuca* is found. The sponge *Hymeniacidon perlevis* (Montagu) forms a green encrustation on the lower parts of the rock.

Between this rock and the Infralittoral Fringe the shore is populated by *Galeolaria, Mytilus, Elminius modestus* and *Chthamalus antennatus.* This belt is very mixed and no single species can be described as dominant.

The Infralittoral Fringe is dominated by *Cystophora uvifera* and *Cystophora torulosa,* with *Sargassum paradoxum, Codium fragile, Hormosira banksii,* and *Enteromorpha.* As at Barnes Bay the algae of the Infralittoral Fringe extend into the Infralittoral for a short distance when they are replaced by a sandy bottom with *Zostera* patches.

The species mentioned above are the only macroscopic animals found on the upper surface of the rocks. The species always appear in cracks at the upper limit of their range but lower down the shore they colonize the unsheltered rocks.

(c) Oyster Cove

The physical environment at Oyster Cove is virtually the same as at Kettering with the exception that the wave action is less, due to the region being more sheltered from northerly winds.

The zonation here is

Bare rock
Lichina
Siphonaria diemenensis
Galeolaria
Hormosira
Cystophora sps.

The most noticeable feature is the complete absence of *Melaraphe unifasciata*, the upper shore being devoid of any large forms.

Lichina confinis forms the first belt found on the shore. This species appears to have a very wide wave-action toleration. In the cracks in the rocks in the lichen belt a few *Siphonaria diemenensis* and *Chthamalus antennatus* are to be found but they do not form a band.

The faunal poverty on this shore is remarkable. The next belt is a very poorly populated strip of *Siphonaria diemenensis* which has a few *Galeolaria* tubes and scattered *Modiolus pulex* Lam. Below this is a belt of *Galeolaria* in which the tubes are scattered very thinly on the rocks. (Plate 2).

There is a marked difference in the shore immediately below the *Galeolaria* belt. The worm tubes form a mixed strip with *Hormosira*, the latter becoming dominant lower down the shore. Living among the *Hormosira* are a few *Mytilus planulatus*. Throughout this and the higher parts of the shore *Austrocochlea* is found in clefts.

The Infralittoral Fringe is dominated by *Cystophora torulosa* and *C. uvifera*. These species do not extend over the Bay bottom which is of sandy mud and supports an Infralittoral growth of *Zostera*. The sandy mud commences at about the level of extreme low water so that the *Cystophora* forms a true Infralittoral Fringe.

The zoning on a pile at the jetty is of interest being as set out below.

1′	4″	Barnacles
	10″	*Galeolaria*
1′	0″	*Pyura*

Bare for a distance of 5 feet to the bottom of the bay.

Another nearby pile showed a zonation of

1′	4″	Barnacles
	5″	*Galeolaria*
1′	3″	*Mytilus* + *Pyura*
1′	0″	*Ostrea* + *Mytilus*.

Sponges to the bottom of the bay.

On these two piles the barnacle belt is composed of the same two species and has the same vertical height. The *Galeolaria* belt, however, has a vertical height of 10″ on one pile and only 5″ on the other. The environment on the piles under the jetty should be the same. The reason for the marked difference in vertical height existing between the two *Galeolaria* belts is probably due to interspecific competition between *Galeolaria*, *Mytilus* and *Pyura*. Only long term observations can decide as to whether the 10″ belt has reached maximum height by the serpulid slowly crowding out other species, or whether the 5″ belt has reached its maximum height as a result of *Pyura* crowding out the serpulid.

The type of shore seen here is fairly typical of that found in nearly all of the very sheltered rocky coasts in Southern Tasmania. The poverty of the fauna in the levels above that occupied by *Hormosira* is one of the most salient features of all the Tasmanian intertidal region. In some places where there is a little spray, *Melaraphe* may be found sparsely distributed on the upper parts of the shore.

(d) On a reef at the Grange, Derwent Estuary

This reef extends out about 60 feet from the shore. The reef is horizontal with the surface at about M.S.L. The seaward end of the shelf is slightly higher than the remainder of the platform. This area will only be described very briefly. It is included because it shows an intermediate condition between the *Cystophora torulosa* and *Lessonia* types of shore.

The *Melaraphe* belt is very poorly developed. Only a few scattered specimens are to be found among the boulders at the top of the shore. Most of the reef surface is dominated by *Galeolaria* with or without *Mytilus planulatus*. There is no *Hormosira* except in pools where there is considerable splash. The reef is too low for the full development of a Barnacle belt but the species are found on the boulders further up the shore. The wave action may be sufficient to cause the boulders to move and so prevent the establishment of any stable life. The upper *Galeolaria* belt has a few *Elminius simplex* and *E. modestus* with some *Siphonaria diemenensis* and *S. zonata*.

On a prominent rock on the reef the barnacle belt is well developed with *Lichina confinis* but there is no *Galeolaria* on the rock.

The mussel beds are extensive and cover most of the seaward end of the reef. Small clusters of mussels are found for some distance up the reef. The mussel beds are not as well developed as at Blackman's Bay and there is not as rich a Cryptofauna below them.

Ulva lactuca forms a partial covering to the beds with *Spirorbis sp.* (? *borealis* (L)) and *Elminius simplex*. Below the mussels are *Cominella lineolata, Patiriella exigua* and *Petrolisthes elongatus*. There are no *Pyura praeputialis*.

The Infralittoral Fringe is dominated by *Cystophora spartioides* with a few *Lessonia plants*. *Hormosira banksii* is also common together with *Cystophora uvifera, C. torulosa* and *Sargassum paradoxum*.

There are no limpets or Coralline belt. The zonation thus is as given below.

Melaraphe
Galeolaria
Mytilus
Cystophora spartioides

but if the prominent rock is taken into consideration the zoning is altered as below.

Melaraphe
Barnacles
Lichen
Galeolaria
Mytilus
Cystophora spartioides

The surface of the reef has numerous scattered shallow pools. These ponds reflect the conditions of the Infralittoral Fringe or of lower parts of the shore. A pool near the landward end of the reef shows basically the same population as the surface of the reef in or near the mussel beds (Plate II) while a pool in the mussel beds has *Cystophora* and other Infralittoral algae. At some time in the future it is hoped to make a study of Tasmanian pool conditions.

(e) At Dodge's Ferry

Dodge's Ferry lies at the entrance to Pittwater, an inlet of Frederick Henry Bay. The water is extremely sheltered, comparable with Kettering or Oyster Cove.

The upper shore is similar to that described at Kettering with the exception that there is a well developed *Melaraphe* and *Bembicium* belt. The shore slopes at a very shallow angle and so allows the slight wave action to cover the maximum amount of shore. The barnacle belt is not very well developed but the *Galeolaria* belt in December 1949 was very thick and broad, the tubes forming encrustations up to 6″ thick on the rocks (Plate II). Living in among these tubes were numerous *Ibla quadrivalvis*. These stalked barnacles are normally small with a short peduncle but in order to survive in the worm tube masses they had developed very long stalks. The *Galeolaria* tubes also sheltered Polynoid worms, *Lasaea australis* and several errant polychaetes.

The mussel beds below the *Galeolaria* are also well developed, being on a scale similar to that seen at Blackman's Bay. The mussels are replaced by the ascidian *Pyura praeputialis* (Plate III). These ascidians form a discontinuous bed along most of the shore. In many cases the ascidians develop " roots " which hold them in position on the rocks (Plate III). The rocks are replaced at low water level by the sandy bottom of the bay. The ascidians cover the rock as far down as the sand.

(f) At Dover

(1) ON THE EASTERN SIDE OF THE JETTY

The Infralittoral Fringe is composed of *Cystophora spartioides, C. torulosa* and *C. uvifera*. In some places the algae are replaced by *Zostera*, but at some other areas there is a dense growth of *Enteromorpha*. The zoning above the Infralittoral Fringe is as indicated below.

Bembicium melanostoma
Siphonaria diemenensis
Galeolaria
Hormosira + *Entermorpha*

The salient feature here is the absence of both the barnacle and mussel belts. *Mytilus planulatus* is found on the shore but it is confined to cracks and does not form a bed. A few *Melaraphe unifasciata* are found on the rocks in the upper part of the *Bembicium* belt but the species does not form a characteristic strip. This may be partly explained by the slope of the shore which suddenly alters into a 4 feet high ledge at the place on the shore where one would expect to find *Melaraphe*. The presence of this ledge would effectively cut off the little spray or wave action that might be obtained on the upper levels of the shore.

Austrocochlea obtusa var. *constricta* is very numerous on the shore. It is found in the *Siphonaria, Galeolaria* and *Hormosira* belts. In the *Hormosira* and Infralittoral Fringe are numerous individuals of the gastropod species *Cominella lineolata*. This species is usually found below the mussel beds at a much lower tidal level than on these rocks. A putrefying sheep which was lying on the shore in the *Siphonaria* belt probably attracted the gastropods since these animals have a strong sense of smell.

The shore is very poor in species, the only large organisms found are *Sypharochiton pellis-serpentis, Patelloida conoidea* and *Siphonaria zonata*. There are also a few *Ulva* plants.

(2) ON THE WESTERN SIDE OF THE JETTY

The zoning is very different from that seen on the other side of the jetty. It is not possible to advance any satisfactory reason for this faunal change, though the shore profile may have some influence in the matter.

There is a horizontal rock platform which permits the slight wave action that exists to reach for some distance up the shore. The zonation is as shown below.

Barnacles
Bembicium melanostoma
Austrocochlea obtusa
Galeolaria
Hormosira

The belts below the *Hormosira* are the same as those seen on the eastern side of the jetty.

The barnacles are of the two species, *Elminius simplex* and *Chamaesipho columna*. The belt is locally sub-divided by isolated patches of *Lichina confinis* and *Rivularia*. In several places the barnacles are not dominant and are replaced by *Bembicium melanostoma*. In the lower parts of the barnacle belt *Patelloida conoidea* and *Austrocochlea obtusa* are found. There are no other species found on this part of the shore.

Austrocochlea is very numerous below the barnacle belt. Other species found in the same region of the shore are *Bembicium melanostoma, Chamaesipho columna, Galeolaria* and a few *Brachyodontes* in cracks. The worm tubes do not occur in a continuous, thick incrustation on the rocks but they form a very prominent band. In clefts in this band are a few small *Mytilus planulatus*. The mussels do not form a belt.

The algae of the Infralittoral Fringe are the same as those seen on the other side of the jetty.

On the shores of Port Esperance (the bay on which Dover is situated near Point Kent the zonation gradually changes to that which is characteristic of more exposed places, with *Xiphophora* dominant in the Infralittoral Fringe. The zones are all raised on the shore but the indicator species do not change with the exception of the Infralittoral algae as noted above.

(g) At the northern end of Roaring Beach

Roaring Beach is on D'Entrecasteaux Channel about eight miles north of Dover. The beach faces south and is not protected from the oceanic swell which pounds on the shore.

The rocks at the top of the north eastern end of the beach show the typical zonation seen on exposed shores. *Sarcophycus* is the dominant alga of the Infralittoral Fringe with a prominent *Corallina* belt above it. The latter consists of *Jania* sps., *Corallina* and the coral-like *Lithophyllum* sp. The latter is not as well developed as at Point Puer but is very much larger than at Betsy Island.

The Corallines are sharply replaced by *Catophragmus polymerus*. There is no *Patelloid* belt although *Siphonaria diemenensis, Patelloida alticostata* and *Cellana limbata* are all present in the *Catophragmus* belt. The barnacles are not well developed being about the same density of numbers as at Sleepy Bay. There is no barnacle belt such as seen on Betsy Island. *Melaraphe unifasciata* is dominant on the upper parts of the rocks.

The sheltered coasts show an even greater poverty of life than other types of shore in Tasmania. This can be attributed to the great increase in actual exposure on the upper parts of the shore where the wave action and spray are reduced to a minimum.

A full comparison of the different types of shore seen in Tasmania will be given in a later paper.

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Fig. 1.—The shore at Little Oyster Cove, showing *Mytilus planulatus* and *Galeolaria* with *Austrocochlea* in the background.

Fig. 2.—The shore at Little Oyster Cove showing the *Galeolaria* belt. The dark patches are *Lichina officinalis*.

FIG. 1.—*Mytilus-Hormosira* pool on the reefs at the Grange.

FIG. 2.—*Galeolaria* masses at Dodge's Ferry. The photograph was taken in December, 1949 before the thick masses were damaged.

FIG. 1.—*Pyura* on the rocks at Dodge's Ferry.

FIG. 2.—An Ascidian, *Pyura praeputialis*, from Dodge's Ferry showing the 'roots' which hold it to the substratum.

The Intertidal Ecology of the Eaglehawk Neck Area

By

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WITH 5 PLATES AND 4 TEXT FIGURES

(Read 15th September, 1952)

Summary

The Eaglehawk Neck area is one of the most important yet seen in Tasmania. All the indicator species of algae are arranged in a linear series according to their toleration for wave action. All degrees of wave exposure are found in the Pirates Bay Area. There is extremely severe wave action on the eastern side of Fossil Island while the western shore of Fossil Island is sheltered and experiences very little wave action.

Introduction

This paper is the fifth of a series on the various features of the intertidal ecology of Tasmania. The first four papers have appeared in this journal and are listed in the references.

Eaglehawk Neck is a very narrow strip of land connecting the Tasman Peninsula with the Forestier Peninsula. It is about sixty miles from Hobart and is on the eastern seaboard of Tasmania.

The area considered at Eaglehawk Neck lies on the eastern side of the neck at Fossil Island and the Blow Hole. (Fig. 1). The shore was examined at various other places where the wave action is modified, including the *Pyura* reefs in Pirates Bay.

Fig. 1.—Outline map of the Eaglehawk Neck area.
Scale—1 inch = 1⅛ miles.

Preliminary visits were made several times between December, 1949 and January, 1951. Detailed examinations were made in February and late March, 1951.

(1) Topography

Pirates Bay is composed of sand with the exception of some reefs at various places as shown on Figure 4. The bay is exposed to fairly severe wave action, but at the eastern side of the bay the wave action is reduced by the presence of Fossil Island.

The wave exposed shore, both on the mainland and Fossil Island, has been cut into a horizontal rock platform of varying width. At the Blow Hole this lower platform extends out about one hundred feet from the base of high cliffs. At the base of the cliffs is a narrow ledge about five feet in height. Between the mainland and Fossil Island this latter ledge enlarges to become a wide shelf. This is the upper platform. Between Fossil Island and the mainland is a narrow shelf which is at the same level as, and continuous with, the lower expanse of rock on the wave exposed coast. On Fossil Island there is only the low level area which is up to one hundred and fifty feet in width. It has large boulders lying on it at the base of the cliffs.

On the wave sheltered side of Fossil Island the wave platform is narrow and becomes less wide the greater the distance from the north end of Fossil Island. Towards the Old Jetty it is absent altogether, the shore being composed of loose rounded stones.

At the northern wave-exposed end of Fossil Island the platform is strewn with large boulders, some of which are 10 feet in height.

(2) Physical Environment

(*a*) *Tides.* There are no tidal records available for Eaglehawk Neck, but the tides are of approximately the same magnitude as at Freycinet Peninsula and Hobart.

(*b*) *Climatic Factors.* The maximum and minimum temperatures at Eaglehawk Neck are shown in Fig. 2. The temperatures are intermediate between those of Swansea and Hobart. There is no temperature recording station maintained at Eaglehawk Neck and these results have been obtained from the Weather Bureau and are based on the interpolation of Swansea and Hobart figures.

The rainfall (Fig. 3) is appreciably higher than that encountered at either Swansea or Hobart. The rain is spread irregularly throughout the year with a maximum in June. June is also a month in which downpours are likely to occur. These range from a sub-normal 0·94″ to 12·55″. Average annual rainfall for 21 years . . . . 34·43 inches.

Although the rainfall at Eaglehawk Neck is higher than that at other places on the East Coast I do not think that has any appreciable effect on the organisms living on the shore.

There are no sea temperature figures available for Eaglehawk Neck, but it is possible that they are closely similar to those found at Freycinet Peninsula, as the major current systems are the same.

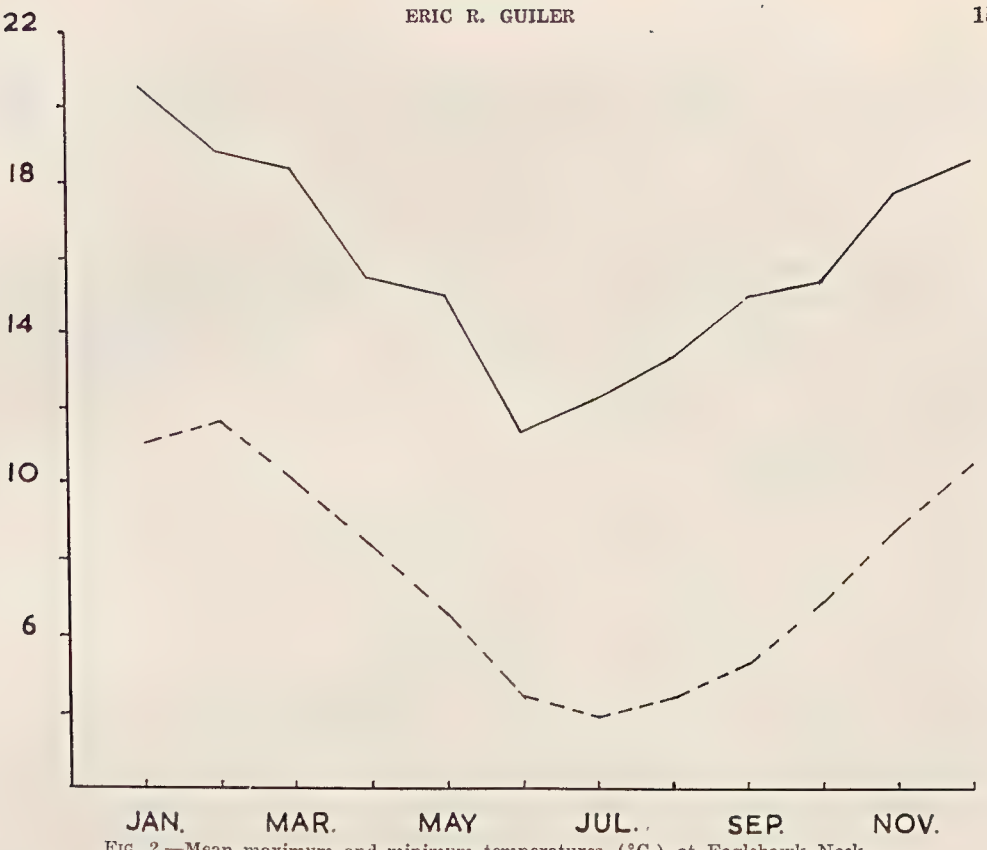

FIG. 2.—Mean maximum and minimum temperatures (°C.) at Eaglehawk Neck.

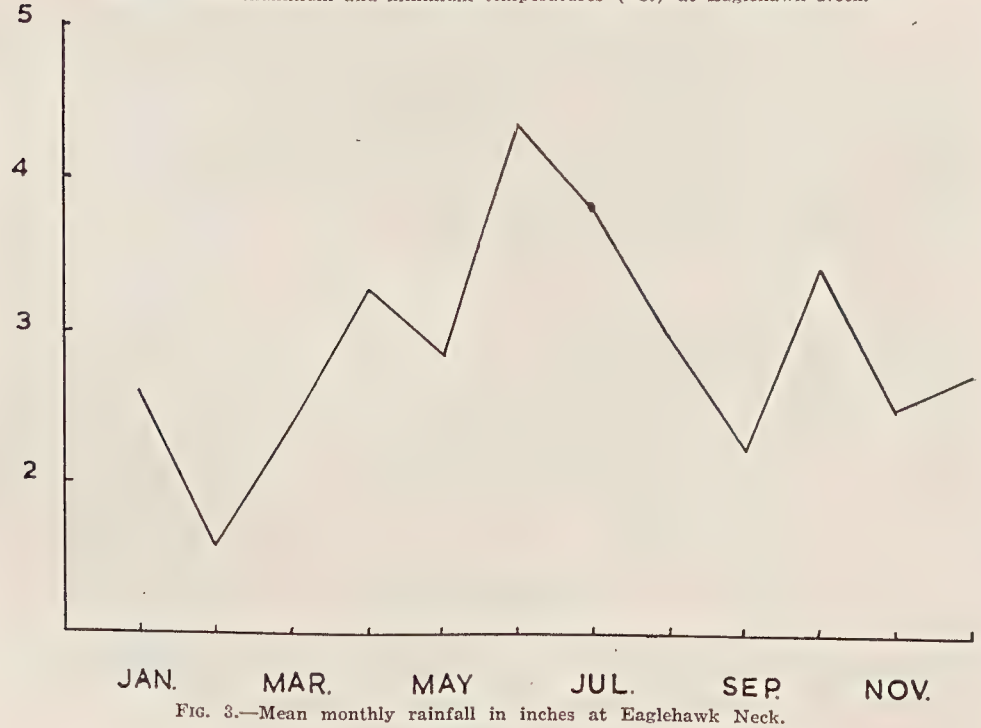

FIG. 3.—Mean monthly rainfall in inches at Eaglehawk Neck.

(*c*) *Geology.* The platforms at both the Blow Hole and Fossil Island are composed of siltstones and sandstones, with some glacial erratics. The bedding is nearly horizontal. There are no major igneous formations.

(3) Zonation

(*a*) *On the wave platform at the Blow Hole*

The intensity of the wave action is a very important factor on the eastern shore of the mainland. The effect of this factor has already been seen at Sleepy Bay. The sedimentary rocks have been eroded into platforms and for this reason it is difficult to obtain a true picture of the vertical zonation as there is a horizontal zonation superimposed on the vertical.

The zonation is:—

Supralittoral	Lichens
Supralittoral Fringe	*Melaraphe unifasciata* and/or *M. praetermissa* (May).
	Chamaesipho columna
Midlittoral Zone	Patelloids
	Corallines
Infralittoral Fringe	*Sarcophycus*

(*a*) Supralittoral

The Supralittoral is populated by a band of orange lichens which in turn are replaced by grey lichens. In some sheltered places a few small and rather stunted *Salicornia* plants are found.

(*b*) *Supralittoral Fringe*

The gastropod *Melaraphe unifasciata* inhabits this area of the shore. On those parts of the cliffs that receive the full effect of the seas this species is either absent or rare. The species is common on the high level platform beside Fossil Island where it lives in hollows and clefts in the rock. During rainy weather these hollows become filled with fresh or brackish water, but this does not appear to cause any serious harm to the Littorinids. Some small scale experiments on the dessication toleration of this species have been carried out and have been described elsewhere (Guiler, 1950).

Another small Littorinid, *Melaraphe praetermissa* (May) is also found in the Supralittoral Fringe. This species is not common at Sleepy Bay but at several places at the Blow Hole where there is intense spray the gastropod is very numerous. It appears to like vertical rock faces about 20 feet or more above M.S.L. where it is drenched with spray. It was not possible to find an area where density counts could be undertaken, but based on eye judgement the number of individuals per square foot must exceed 100. In some areas both this species and *M. unifasciata* occur together. The vertical cliffs favoured by *M. praetermissa* are usually devoid of the other species.

(*c*) *Midlittoral Zone*

All of the Midlittoral region falls on the horizontal platform. The salient feature of this region is the absence of barnacles as the dominant form over part of its area. The barnacles are only found in small numbers

at the top of the Midlittoral on the vertical rock face between the upper and lower platforms. Over most of the lower platform the limpet-like *Siphonarias* are the dominant form. The surface of the platform is irregular and there are many pools of shallow depth. In these pools is a *Jania* turf (Plate I). The presence of so much *Corallina* material obscures the zonation and a detailed examination has to be carried out in order to identify the zones. The almost constant swell causes waves to break across the platform and pools are nearly always filled with water and often the platform is covered with about 1 inch of water so that it is difficult to define the limits of the ponds. It is sufficient to say that they are very numerous and in places, continuous.

The barnacle *Chamaesipho columna* (Spengler) is found on the vertical rock as noted above and also in small patches at the landward end of the lower platform. The barnacle is not numerous and is only dominant for about 15 feet of the platform.

The barnacles are soon replaced by Patelloids. Most of the area of the platform is occupied by these organisms, of which the most numerous species are *Siphonaria diemenensis* and *S. zonata.* These species are gregarious in nature and form patches of up to 100 individuals. In the lower part of the Patelloid belt the large limpet, *Cellana limbata* (*Philippi*), is found. Also occurring in the Patelloid belt are *Patelloida marmorata* (Ten-Woods) and *Patelloida cantharus* (Reeve). The barnacle *Chamaesipho columna* is found in this belt. The lower part of the Patelloid zone is invaded by *Catophragmus polymerus* and the calcareous algae.

It is interesting to speculate what the fauna of such a platform as this would be if the water were calmer. The continual inundation of the platform by heavy waves probably assists the limpets by permitting the growth of their algal food, and so extending their range much further up the platform than would normally be the case. The presence of small groups of *Chamaesipho* over a large part of the Patelloid belt points to the fact that this species would probably be the dominant species under conditions of less wave action. These barnacles do not occur in such numerous clusters in the Patelloid belt in other parts of Tasmania. It seems that the great extension of the Patelloid belt is a local feature made possible by the wave action keeping the platform wet at nearly all phases of the tide.

The Patelloid belt is replaced by the calcareous algae. This belt extends up to 20 feet from the seaward edge of the platform. The upper part of the *Corallina* belt is occupied by the coral-like *Lithothamnion* sp. referred to in a previous paper (Guiler, 1951*b*). This species is *Lithophyllum hyperellum* Foslie and has been identified for me by Dr. H. B. S. Womersley. This alga forms a thin strip around the edge of the belt. Both the dome shaped and encrusting forms are found but neither are as large as at Sleepy Bay or, as will be seen later, Port Arthur.

The dominant alga in the lower *Corallina* belt is a *Jania* sp. with *Corallina cuvieri.* These species from a close turf which prevents other forms from colonizing the rock. Living among the algae are Sphaeromid isopods, *Lasaea australis* and errant Polychaetes. The *Corallina belt* ends at the Infralittoral Fringe where it is replaced by *Sarcophycus potatorum* (Labill.) Kütz.

Due to the steep drop off the edge of the platform into deep water it was not found possible to examine the Infralittoral Fringe in detail. The swell prevents the use of a boat. Around the holdfasts of the alga the encrusting algae form a thin incrustation on the rocks.

The ascidian *Pyura praeputialis* (Heller) occurs at the seaward end of the platform among the holdfasts of the kelp. This is the first place examined on a wave exposed coast where this species has been encountered in quantity. The tunicate does not form a continuous sheet but is found in clusters of up to 12 to 20 individuals.

At the entrance to the Blow Hole the macroscopic algae show an interesting zonation. The force of the waves sharply diminishes the greater the distance up the tunnel from the sea. Thus, there is a horizontal zonation of the algae starting with *Sarcophycus* on the exposed shelf. Following the *Sarcophycus* belt with little intermixing is *Lessonia corrugata* which in turn is replaced by *Xiphophora billardieri* Mont. A similar zoning is to be seen on the mainland side of Fossil Island, where the wave action is reduced.

On the lower platform there are two deep ponds. One of these is particularly interesting as it contains algae which are characteristic of more sheltered places. The dominant alga in the pond is *Phyllospora comosa* but there are also several large masses of *Lessonia corrugata*. *Cystophora spartioides* (Turn) J. Ag. is also found in the pool as well as one plant of *C. torulosa* (R. Br.) J. Ag. The presence of this latter plant is of especial interest in view of the fact that the species is usually found in sheltered places. The bottom of the pond is thickly carpeted with *Ulva lactuca* L.

Parts of the coralline zone are thickly colonized by *Ulva lactuca*. This species is most common at the seaward edge of the platform. Also found in the coralline belt is the finger-like alga, *Adenocystis lessonii* Hooker and Harvey.

The exposed platforms on Fossil Island were examined but differed only in minor detail from the above description. The Fossil Island platform is wider than that at the Blow Hole and consequently there is a wider *Chamaesipho* belt on Fossil Island. The limpet *Cellana limbata* extends further up the shore on Fossil Island, being found at the base of some large boulders which are scattered on the landward end of the platform.

(*b*) *On the sheltered side of Fossil Island*

There are two separate forms of zonation to be considered under this heading. The most important form is the horizontal zoning of the algae of the Infralittoral Fringe as seen on the Pirates Bay side of Fossil Island from the Old Jetty to the northern end of the island. The second series of zones is the ordinary vertical zonation found on various parts of the shore.

The Horizontal Zonation

The northern point of Fossil Island is exposed to the full effect of wave action. The shore is composed of large boulders with numerous ponds. The dominant alga in this area is *Sarcophycus potatorum* and the Infralittoral Fringe is similar in constitution to that seen at the Blow Hole. In places where the wave action is slightly reduced, *Phyllospora*

comosa is found associated with the *Sarcophycus*. With further reduction in wave action *Lessonia corrugata* appears. This species does not form a particularly well defined belt on the shore, but it is very common. The conditions suitable for this species do not appear to be present over a sufficient area to allow *Lessonia* to form a belt.

Xiphophora billardieri forms quite a long belt where the wave action is reduced. It forms the dominant alga over a large part of the sheltered side of Fossil Island. It is frequently mixed with *X. chondrophylla* (R. Br.) Mont. The latter species is more common where the wave action is slightly less than the maximum tolerated by *X. billardieri*. *Phyllospora* is found with both of these species. At one place in the *Xiphophora* belt there is a patch of *Sarcophycus*, but there are only a few *Lessonia* plants.

The *Xiphophora* sps. give way to *Cystophora spartioides*. There is considerable mixing of the three species and the *Cystophora* never becomes a pure belt. *C. spartioides* is replaced by *C. uvifera*. These two algae form a belt over most of the western end of the Infralittoral Fringe on Fossil Island. At the Old Jetty the algae are partially replaced by *Ecklonia radiata* (Turn) J. Ag. and *Phyllospora*. The two *Cystophora* species as well as *C. torulosa* are found among these larger algae.

In some restricted localities *Zostera nana* forms a thick carpet. This plant occurs in the Infralittoral as the beds are not exposed at low water.

In general, this area may be considered to be the most important yet examined on a rocky coast in Tasmania. All of the indicator species of algae are present in a continuous series and it is possible to build up a picture of the horizontal zonation of the algae as controlled by wave action. At Port Arthur all of the species are represented but not in a continuous series. The distribution of the algae is shown on Figure 4.

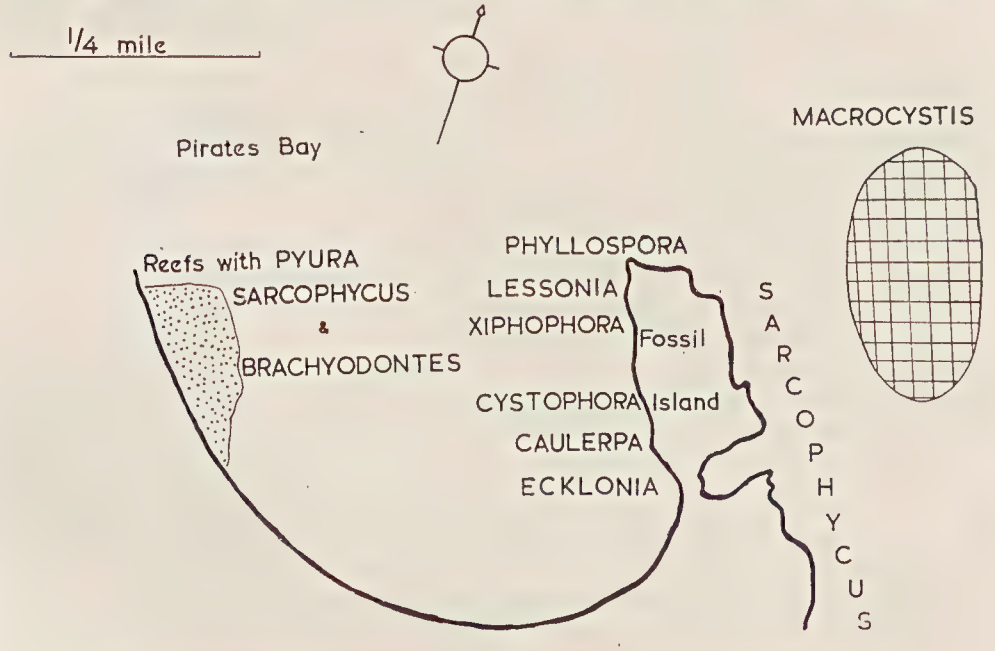

FIG. 4.—Map showing the distribution of the important wave action indicator algae at Eaglehawk Neck and Fossil Island.

The zoning of the algae of the Infralittoral Fringe and their relation to wave action may be summed up as below in Table 1. The figures for the intensity of wave action are only approximate and apply only to the Eaglehawk Neck area.

TABLE 1

The relation of Infralittoral Fringe algae to wave action at Eaglehawk Neck.

Algae.	Wave Action Range
Sarcophycus (neglecting the patch on the western shore of Fossil Island)	o. (0-11). 4. a, 3 to o. (0-11) 2. a,2.
Lessonia	o. (0-11). 4. a, 2 to s. (1-8) 2. b,3.
Xiphophora sp.	s. (0-11). o. a, 2 to s. (1-8) 2. b,3.
Cystophora spartioides	s. (1-8). 1. b, 3 to s. (1-8) 0. b,3.
Cystophora torulosa	s. (1-8). 0. b,3.
Cystophora uvifera	s. (1-8). 0. b,3.

In ponds at the seaward end of Fossil Island there is an algal flora which differs with the degree of wave action experienced by the ponds. In the pools at the outer edge of the boulder patch the flora and fauna is not modified from that seen in the Infralittoral Fringe. These ponds are always being filled by large waves and may be considered as upward extensions of the Infralittoral Fringe. *Lessonia* appears in ponds further away from the heavy waves, but it is soon replaced by *Xiphophora* which in turn is replaced by *Hormosira banksii*. The cryptofauna and flora of the ponds is composed of encrusting forms. *Lithothamnia* are very common and also sponges such as *Sycon gelatinosum* (Blainville), *Hymeniacidon perlevis* (Montagu) and *Tethya diploderma* (Schmidt). Many of the species found in the cryptofauna are not found in the Infralittoral Fringe but are confined to the less disturbed Infralittoral.

Chapman (1941) notes that algae found in ponds are of two types, those found in the Sublittoral and those which are characteristic of ponds. Evans (1949) noted that the intertidal cryptofauna is an extension of the *Laminarian* zone. Both of these remarks are only partly true for the ponds at the northern end of Fossil Island. The dominant algae of the ponds on Fossil Island are not truly Infralittoral in origin but reflect the conditions found in the Infralittoral Fringe. As the wave action experienced by the ponds decreases, either in severity or period of endurance, so do the dominant algae become more characteristic of sheltered conditions on the shore, until ultimately *Hormosira*, found in the lower Midlittoral of sheltered shores, is the dominant pond alga.

It must be stressed that there is little difference in the heights of the ponds on the shore. In a distance of 20 yards at the northern end of the island we find in the ponds a picture of the horizontal algal zonation on the Pirates Bay shore of Fossil Island.

Chaetomorpha darwinii (Hook). Kütz is found in most of the ponds at the end of Fossil Island. The smaller *Chaetomorpha aerea* (Dillw.). Kütz forms dark green tufts in pools, especially those with more than one foot of water. Both these species are found on more sheltered parts of the coast.

Caulerpa brownii Endl. is present in some of the ponds at Fossil Island. It favours the more sheltered places and is quite plentiful in the *Cystophora uvifera* belt near the old jetty. It lives in the upper limits of the Infralittoral and forms dark green ' bushes '.

The Vertical Zonation

At the place marked A on Figure 1 the vertical zonation on the shore is indicated as follows:—

Melaraphe unifasciata	Supralittoral
Chamaesipho columna	Midlittoral
Cellana limbata + *Actinia tenebrosa*	
Patelloida marmorata + *Siphonaria diemenensis*	
Ulva lactuca + *Corallina* + *Jania*	
Cystophora spartioides	
Xiphophora billardieri, X. chrondrophylla + *Sarcophycus* and *Phyllospora*	Infralittoral Fringe

The Infralittoral Fringe is of interest as the transect is at one of the critical places on the shore where the change-over from one dominant species to another takes place. Thus we find algae of both exposed and sheltered coasts. In such a situation the algae which are characteristic of the less exposed situations tend to occur higher on the shore than their normal position. Thus, *Cystophora* forms a thin strip above the Infralittoral Fringe. The other species occurring on exposed shores are found at a slightly lower level than usual. This feature will be seen at the Old Jetty, where *Ecklonia* occurs much further down the shore than normal.

The zones seen in the Midlittoral are different from those previously seen anywhere in Tasmania. *Ulva* forms a definite band with the corallines at the lower limit of the zone. This species illustrates the influence of seasonal changes on the distribution and density on the shore. At other seasons of the year this belt may be dominated by the corallines. The corallines are *Jania* sp. and *Corallina cuvieri*. The corallines form a more open turf than that found on the exposed shore. This is especially noticeable in ponds. (Plate I).

The Patelloid belt is well developed, but the dominant species are different from the usual type found on this nature of shore. *Patelloida marmorata*, found in the lower part of the belt, is usually characteristic of more exposed coasts but here it is a co-dominant with *Siphonaria diemenensis*. The lower part of the Patelloid belt is not strikingly different from the general condition of the belt as found on any semi-exposed or exposed shore, but the upper Patelloid belt is very different from anything yet seen. The large limpet *Cellana limbata*, becomes dominant in this region. The red anemone, *Actinia tenebrosa*, is extremely plentiful in the same area and ranks as a co-dominant. Both these species are found in parts of the shore where water is retained at low tide or else on sun sheltered faces. The topography of the platform is such that they are permitted to form a belt. Plate II shows a typical concentration of the anemones. The usual habitat of anemones is in cryptic or semi-cryptic places and the limpet favours similar situations or else is found bordering ponds (Plate II).

The barnacle *Chamaesipho columna* is the only barnacle found on the upper part of the shore. The species is not numerous but forms fairly large groups of individuals in various places on the shore.

As at most other transects the littorinid *Melaraphe unifasciata* is the only macroscopic organism in the Infralittoral Fringe. The Supralitoral is composed of bare rock.

In some places a bunodactid anemone forms carpets on the rocks. These carpets are usually found in the middle of the Midlittoral (Plate II) but in some instances the carpets are found in the Infralittoral Fringe. Cracks in the rocks are also occupied by this species. The anemone is dark chocolate in colour and when densely packed in cracks it has the appearance of an alga.

The mussel *Brachyodontes rostratus* inhabits the clefts in the rocks as well as forming isolated patches. Due to the density of colonization of cracks by both species, *Brachyodontes* and the anemone do not inhabit the same cracks.

The 'limpets', *Patelloida diemenensis, Siphonaria diemenensis* and *S. zonata,* all migrate in search of food, each returning at low water to their 'homes' (Plate III).

At the northern end of Fossil Island the vertical zonation is obscured by the broken shoreline of large boulders, and also by the superimposed diminishing wave effect as the distance from the Infralittoral Fringe increases. Examination of a transect yields peculiar results with *Sarcophycus* and *Hormosira* dominant at the same level but different places on the shore. However, the basic zonation is much the same as that seen at the Blow Hole, with the important exception that in the upper Patelloid belt there is a band of *Rivularia* sp. This dark green, button-like alga does not like heavy surf. It is found on stones which get some spray but not a lot of wave action. The alga does not form a continuous band but when it occurs it is usually very plentiful.

Towards the Old Jetty near the end of the platform on Fossil Island (A on Fig. 1) the lower Midlittoral is dominated by *Hormosira banksii* with a few *Galeolaria* tubes. The Infralittoral Fringe is composed of the *Cystophoras* noted above and *Caulerpa brownii.* The anemone carpets are not as well developed here as at further along the platform towards the northern end of the island. The anemones probably demand a certain amount of broken water such as is obtained from the backwash of waves sweeping round the point of Fossil Island. The other anemone, *Actinia tenebrosa* and the large *Cellana* limpets also seem to have the same requirements as they are not so numerous here as at A.

The *Cellana-Actinia* belt is absent. The zonation here is indicated below—

Melaraphe unifasciata
Barnacles
Patelloid
Hormosira banksii
Corallines
Cystophora

At the Old Jetty the shore is composed of rounded stones up to one foot in diameter embedded in a gritty mud. This type of substratum renders the vertical zonation more difficult to determine due to the abundance of semi-cryptic places.

The *Melaraphe* belt is not well developed in this area. There is probably insufficient spray to support a large littorinid fauna. Barnacles are local in distribution but all are *Chamaesipho.* The Patelloid belt is the most well developed on the shore and it is separated from the algae of the Infralittoral Fringe by a coralline turf with a few *Hormosira* plants.

One conspicuous feature of the shore at the Old Jetty is the presence of a broad band in the upper barnacle belt which is populated by the gastropod *Austrocochlea obtusa* (Dillwyn). The variety found here has strong ribs round the shell and was formerly named *A. constricta.* The species is particularly plentiful in the neighbourhood of decaying plant matter and numbers as many as 12 per square foot.

The zonation here is indicated as follows—

Melaraphe unifasciata
Austrocochlea obtusa
Barnacles
Patelloids
Corallines
Cystophora-Xiphophora-Phyllospora-Ecklonia.

The algae of the Infralittoral Fringe fall into five dominant species. *Phyllospora comosa, Cystophora spartioides, C. uvifera, Xiphophora chrondrophylla,* and *Ecklonia radiata. Cystophora spartioides* is dominant inshore and is mixed with *C. uvifera.* The *Phyllospora* and *Ecklonia* form a mixed association at the lower limits of the fringe beside the Old Jetty. Between the *Ecklonia* and the *Cystophora* is a wide strip of weed dominated by *Xiphophora chondrophylla.* These weed belts are not sharply differentiated from each other as there is much mixing of the species. *Cystophora uvifera* occurs with *Phyllospora* and other algae but *Ecklonia* does not occur in the *Xiphophora* and *Cystophora* belts. Other generally distributed algae are *Lithothamnia, Corallina cuvieri, Jania* sps., *Caulerpa brownii, Caulerpa sedoides* (R. Br.) Ag., *Colpomenia sinuosa* (Roth.) Derby & Sol., *Codium tomentosum, Ulva lactuca* and a few *Hormosira* plants. The latter are found in the upper part of the Infralittoral Fringe and the lower part of the Midlittoral.

The boulders do not form a suitable substratum for animals, but in places the anemone *Actinia tenebrosa* is very numerous. *Cellana* is also found. The common crab on the upper part of the shore is *Cyclograpsus punctatus* (M-Ed.) while at lower levels such species as *Lomis hirta* and *Naxia spinosa* are found. The encrusting sponges listed as occurring at Fossil Island are all found here. One species which is scarce at other places on the western shore of Fossil Island is very numerous in this area, namely, the serpulid *Galeolaria caespitosa.* Its tubes form a white band around the lower part of the boulders and stones found on the shore. Some mussels, *Mytilus planulatus,* are found but they do not form beds and are not sufficiently numerous to form a zone.

Several algae species occur scattered along the sheltered shore of Fossil Island. These species are found in the lower Midlittoral or the Infralittoral Fringe. The species are *Caulerpa brownii, Chaetomorpha darwinii, C. aerea* and *Codium tomentosum. Hormosira banksii* is also found at various places on the shore, but this species is restricted to the Midlittoral except at the Old Jetty.

(*c*) *On the Reefs in Pirates Bay*

About a mile along the shore from the Blow Hole towards Eaglehawk Neck there is a series of low reefs which extend out for a short distance into the bay.

These reefs are of considerable importance as they throw some light on the distribution of two intertidal species. In particular, they give an index of the wave action toleration of the ascidian *Pyura praeputialis* and the mussel *Brachyodontes rostratus*.

The dominant form over nearly all of the reefs is *Brachyodontes rostratus*. The parts of the reef nearest the top of the shore are populated by *Melaraphe unifasciata*. The gastropod is replaced by a poor barnacle population. The latter is replaced by an open *Galeolaria-Brachyodontes* belt (Plate III). The mussels soon become the dominant species and cover the rocks in a densely packed sheet. In lower parts of the reef *Catophragmus polymerus* uses the mussels as a substratum, but the mussels do not offer a habitat to other forms.

At the end of the reef the mussels are replaced by *Pyura*. (Plate IV). In some places there is a thin band of *Laurencia* sps. separating these two species. The water at the edge of the reef is shallow and at low tide on a calm day it is probable that the ascidians are completely exposed. Another ascidian found on these reefs is the stalked ascidian *Boltenia pachydermatina* (Herdman). The presence of sand all round these reefs does not seem to reduce the mussel population. In many places on the reef, mussels living in cracks are embedded in sand and during gales considerable quantities of detritus, weed and sand must be deposited on the reef. The presence of moving sand probably accounts for the poor *Galeolaria* population.

At some places on the reefs *Sarcophycus* is found at the same level as the ascidians. (Plate IV). This is important as it enables us to state that *Pyura* occurs on these reefs in the Infralittoral Fringe, *Sarcophycus* being characteristic of that level.

It is worth noting that there are very few Patelloids, certainly not sufficient to warrant describing a Patelloid belt. *Siphonaria diemenensis* and *S. zonata* are found as well as *Patelloida alticostata*. A few *Cellana limbata* occur in clefts. Similarly, there are no coralline algae or other lower Midlittoral forms.

The zonation on these reefs is indicated as follows:—

Melaraphe unifasciata
Barnacles
Galeolaria + *Brachyodontes*
Brachyodontes
Pyura with or without *Sarcophycus*
or
Melaraphe
Barnacles
Galeolaria + *Brachyodontes*
Brachyodontes
Laurencia
Pyura

Notes on the Port Arthur Area

All types of coast are found in the Port Arthur area. The wave exposure varies from intense to slight. On the coast at Remarkable Cave and on the eastern side of the entrance to Port Arthur the wave

action is very strong. In the harbour of Port Arthur the wave action is negligible. All grades of wave action between these two extremes are found within the area of water called Port Arthur. The grades of wave action are not arranged in a linear series as at Eaglehawk Neck.

In the entrance to Port Arthur and at various places within the Port, notably Opossum Bay off Point Puer, and Frying Pan Island, the kelp, *Macrocystis pyrifera* is found in large off-shore beds. The effect of this species in modifying the wave action has already been noted. The seaweed is kept afloat at or near the surface by bladders and just below the surface of the sea is a mass of bladders and fronds. Often found with the *Macrocystis* is a *Sargassum* sp. which frequently has a vivid red encrusting bryozoan on it. This mass of weed near the surface deadens the intensity of the wave action but it is difficult to estimate its effect on the shore. It certainly reduces and often eliminates ' white horses '. *Macrocystis* is subject to considerable seasonal variations in the size of the beds. Work on this aspect of algal ecology is being carried out by Mr. Cribb, of C.S.I.R.O. It has been observed that growth takes place during the winter and spring, which would give the maximum protection to intertidal animals. In summer, judging by my own irregular observations on the Eaglehawk Neck kelp beds, the area of sea occupied by the kelp suffers considerable reduction. This would allow the maximum possible wave action which in turn would cause spray on the shore and so alleviate the effects of dessication and exposure on the shore. I consider that while the presence of *Macrocystis* reduces the amount of broken water that reaches the shore, it does not greatly reduce the effect of the ocean swell. It is not possible to measure the strength of the swell before and after the passage through the kelp beds. A lot more information is required on seasonal variation of the density per unit area of the plants and the migration of the beds.

Point Puer

At Point Puer there are two main types of shore. The wave exposed coast is cut into three platforms. The upper platform is at the foot of high cliffs and is only a few feet in width. Most of the shore area is on the second platform. This platform is at a level equivalent to the coralline zone. The third platform is some four feet below the second and is only two or three feet in width. Because of the heavy swell it is inaccessible in all but the calmest weather.

On the edge of the lowest shelf the dominant form is *Sarcophycus potatorum*. This species likes places where there is a horizontal or near horizontal shelf offering a firm substratum. *Phyllospora comosa* occurs in the water immediately beside the *Sarcophycus*. I was unable to determine the substratum to which the *Phyllospora* was adhering. In general, the flora and fauna of the Infralittoral Fringe is very similar to that found at the northern end of Fossil Island.

At the seaward edge of the second platform there is a very rich growth of the coral-like *Lithothamnion* sp. This species appears to reach its maximum development in this part of Port Arthur. On other parts of the eastern shore of Tasmania the species is not as well developed,

either in size or in numbers. The dominant form is the dome but the encrusting variety is also present. (Plate IV). The rock is densely populated by both larger and small colonies.

The largest or second platform is covered by a coralline turf with *Patelloida marmorata, Siphonaria diemenensis, Cellana limbata* and *Plaxiphora albida.*

The second type of coast found at Point Puer is a sheltered shore on the northern side of the point. There is a nearly horizontal platform which is covered by a very considerable growth of *Hormosira banksii.* This is easily the largest area covered by this alga yet encountered in Tasmania. The *Hormosira* is of sufficient size and density to justify the use of the term Hormosiretum.

Frying Pan Island

This area shows a gradation of algae from *Xiphophora* on the exposed eastern side of the island to *Cystophora* sps. in the shelter of Lady Bay. This species is in the Infralittoral Fringe and is immediately replaced by a very dense population of the surf barnacle, *Catophragmus polymerus.* (Plate V). Separating the barnacle from the alga is a narrow strip of bare rock. This rock is kept bare of life by the constant sweeping action of the seaweed. The formation of the rock undoubtedly assists the growth of this latter species. There is some swell which comes in from the entrance to Port Arthur so that there is always some surf breaking across the rock. Living in clefts in this rock are numbers of the mussel *Mytilus planulatus.*

On rounding the corner of Frying Pan Island the *Xiphophora* + *Phyllospora* is replaced inshore by *Ecklonia radiata.* The *Ecklonia Phyllospora* junction can be picked out on the shore by a large tree lying partly in the water. The *Ecklonia* does not occupy a large area but is soon replaced by *Cystophora cephalornithes* and *C. spartioides.*

The vertical zonation in Lady Bay is shown below—

Melaraphe unifasciata
Bare rock
Lichina confinis
Barnacles
Rivularia
Galeolaria
Galeolaria + *Hormosira* + *Ulva* + *Codium fragile.*
Cystophora sps.

It is doubtful if the barnacle belt can be called a true belt. The barnacles are very few in numbers and are found in isolated patches, of ten in cryptic or semi-cryptic places. The species found are *Chamaesipho columna* and *Tetraclita purpurascens.*

At Opossum Bay

The zoning here is different from that seen at Lady Bay and Frying Pan Island. The wave action is certainly less than that encountered on the exposed shore of Frying Pan Island but it is probably more than that encountered at Lady Bay.

As at Lady Bay, the barnacle zone is greatly reduced, the barnacles being confined to cryptic places. It is better to speak of bare rock with barnacles in clefts rather than of a barnacle zone. The zoning is as follows—

Bare rock
Lichina confinis + *Melaraphe unifasciata*
Siphonaria diemenensis (in hollows in the rock)
Bare rock with *Tetraclita purpurascens* in clefts
Galeolaria caespitosa
Galeolaria + *Hormosira banksii*
Hormosira + *Cystophora torulosa*
Cystophora sps.

This zonation is shown in Plate V. Slightly to the east of the locality of Plate 5 there is a small point where there is more wave action. *Phyllospora* replaces *Cystophora* in the Infralittoral Fringe but *Hormosira* is present at higher levels of the shore. The *Hormosira* at this point is very well developed, with large strong plants. It is worth noting that there are no mussel beds on this point. Mussels, *Mytilus planulatus* are found further along the shore towards the sandy part of Opossum Bay. These mussels do not form well developed beds, but are in large clusters arranged along small escarpments caused by erosion along the bedding planes.

Remarkable Cave

The shore at Remarkable Cave lies on the oceanic coast a few miles beyond Point Puer. The area is interesting ecologically on account of the presence of packed beds of the ascidian *Pyura praeputialis*. These animals live among the holdfasts of the kelp *Sarcophycus*. It is very difficult to examine the Infralittoral Fringe on account of the heavy swell. When an examination was attempted the sea was very smooth but there was a low swell causing up to twelve feet rises of water-level on the shore.

The small mussel, *Brachyodontes rostratus*, also is found in large numbers in this area. The species does not form the dense incrustations such as seen in Pirates Bay but it is a very noticeable feature of the lower Midlittoral belts.

The Port Arthur region covers a considerable area of ground and these notes are not intended to be a survey of this area but merely to mention one of two interesting ecological features. Mr. A. Cribb of C.S.I.R.O. is carrying out a detailed survey of the area and for that reason I have not attempted any major work at Port Arthur.

Discussion

One of the most interesting features of the wave exposed coasts in Tasmania is the presence of the extensive off-shore beds of *Macrocystis*. This alga, as noted above, has a considerable effect in modifying the wave action, but this effect is difficult to evaluate.

The presence of these off-shore beds of kelp is a feature found only on Pacific and Southern coasts. On the eastern seaboard of North America there are extensive kelp beds which have been described by

Andrews (1945). At Monterey these beds are composed of two species, *Macrocystis integrifolia* Turn. and *Nereocystis luetkeana* Martens with other species of lesser importance. The same author (1925) described the kelp beds at Puget Sound. Shelford (1935) also described the Puget Sound beds.

One of the conclusions reached by Andrews at Monterey is that the weed checks currents and wave action. A most interesting feature of his conclusions is that the major numbers of the animals found on the weed are immature forms of the fauna of the adjacent sea floor. It is not beyond possibility that beds which are found close to the shore might influence the fauna of the Infralittoral Fringe.

In South-West Africa the kelp beds are composed of *Ecklonia buccinalis*, *Laminaria pallida* and with *Macrocystis pyrifera* important in local areas (Stephenson, 1939).

In Australia, *Ecklonia radiata* is found on the warmer coasts but this species is not as large as *Macrocystis* and occurs in either the Infralittoral Fringe or the immediate Infralittoral. This species would probably have no greater effect on the wave action than any other species. In Tasmania, *Ecklonia* is found in sheltered places, *Macrocystis pyrifera* being the kelp of exposed coasts.

The parts of the coast considered in this region of Tasmania are the most important examined to date. In particular, the zoning of the algae in relation to the intensity of wave action is seen very fully at Fossil Island. All of the indicator algae of Tasmania are seen in their relative positions of wave toleration. The series is thus . . . . *Sarcophycus*, *Sarcophycus* + *Phyllospora*, *Lessonia*, *Xiphophora*, *Ecklonia*, *Hormosira*, *Cystophora*. The relative position of *Lessonia* was in considerable doubt until the Eaglehawk Neck area was examined. The latter locality shows that the species requires slightly less wave action than *Sarcophycus*, although the exact conditions are not reproduced at Fossil Island.

The area is also important as it gives a picture of the habitats of the ascidian *Pyura* and the mussel *Brachyodontes rostratus*, both of these species being found on reefs in Pirates Bay. It also gives an outline of the wave action toleration of these species.

As at Freycinet Peninsula, the upper parts of the shore are very poorly populated, but the barnacle fauna is greater than at Sleepy Bay and Coles Bay areas. The physical environment at Eaglehawk Neck is similar to that encountered at Freycinet Peninsula so there must be some other reason for the poverty of the barnacle fauna at the latter place. The distribution of barnacles in Tasmania will be discussed later.

The various zones as seen on the shore will be correlated with those seen elsewhere in a later paper.

Acknowledgments

I am indebted to Professor V. V. Hickman for reading the typescript of this paper and for his interest throughout its preparation. The cost of travelling was met by a Commonwealth Research Grant. Some of the work was carried out at the annual camp held by the Tasmanian Field Naturalists Club.

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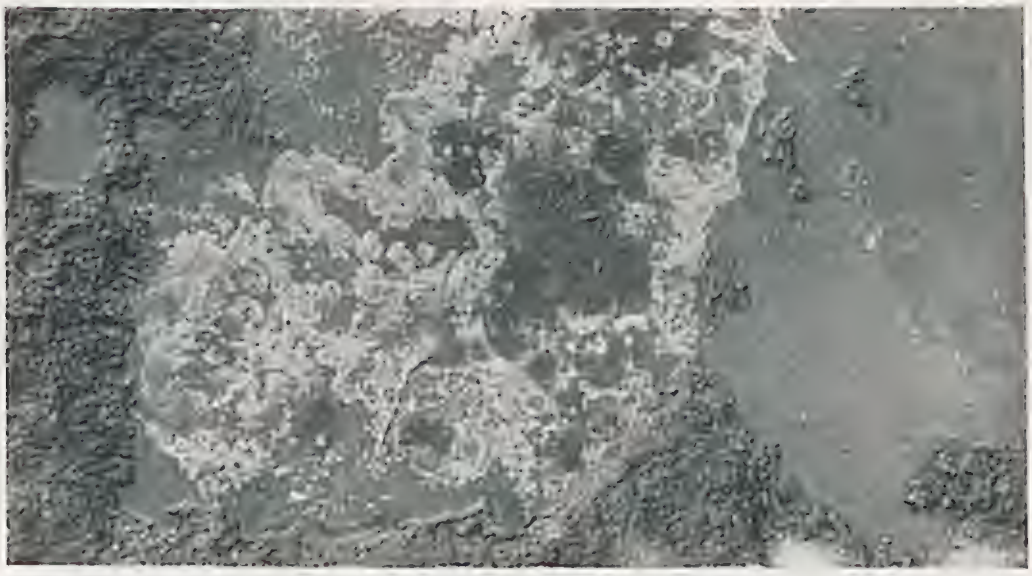

Fig. 1.—*Jania* turf of the exposed platform at the Blowhole, Eaglehawk Neck. Note the close, short nature of the alga.

Fig. 2.—The *Jania* turf on the sheltered side of Fossil Island. The alga is larger and the turf is more open. The barnacles on the overhanging rock are *Tetraclita*.

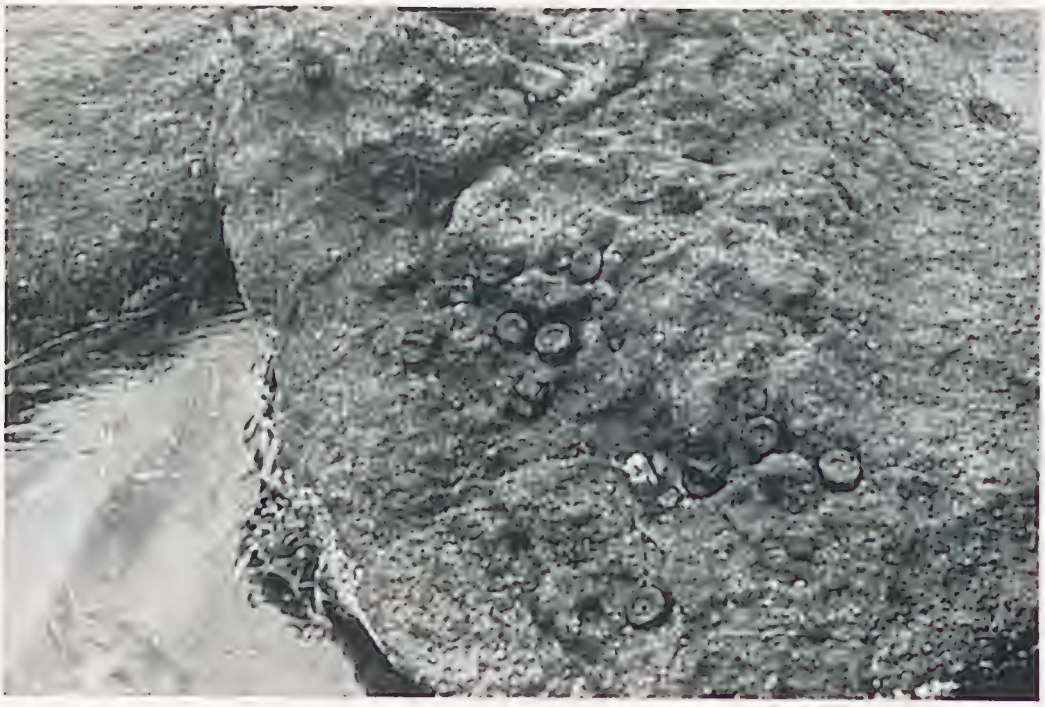

FIG. 1.—*Actinia tenebrosa* at the northern end of Fossil Island.

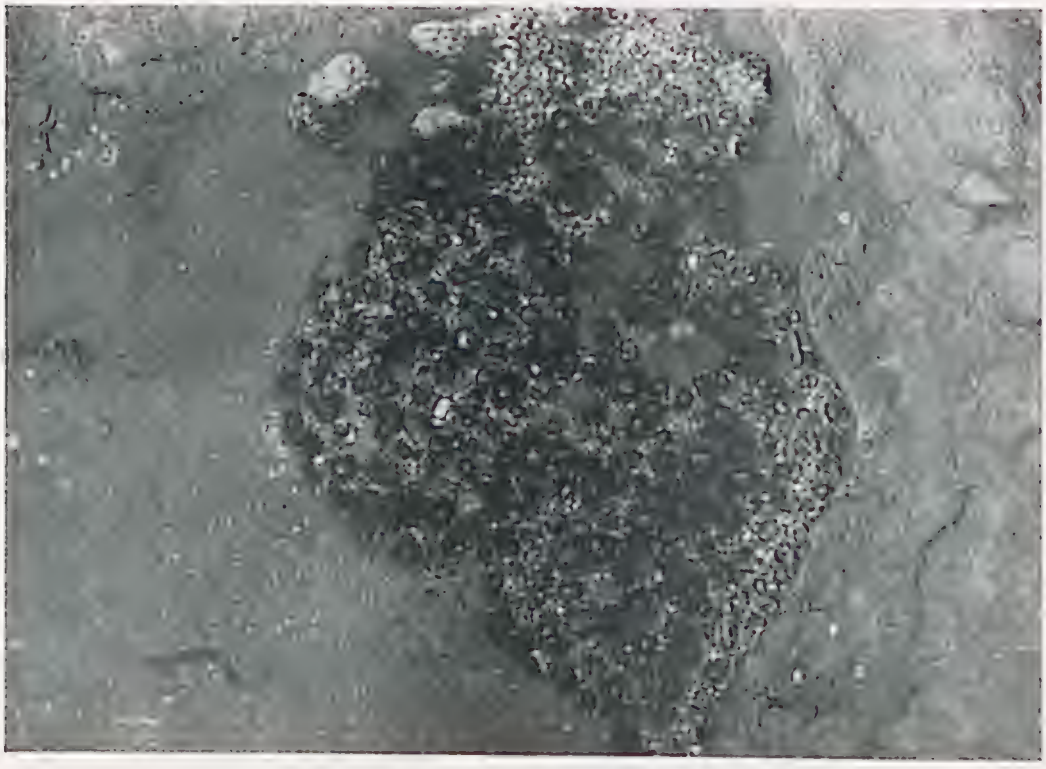

FIG. 2.—Anemone carpet on the sheltered side of Fossil Island.

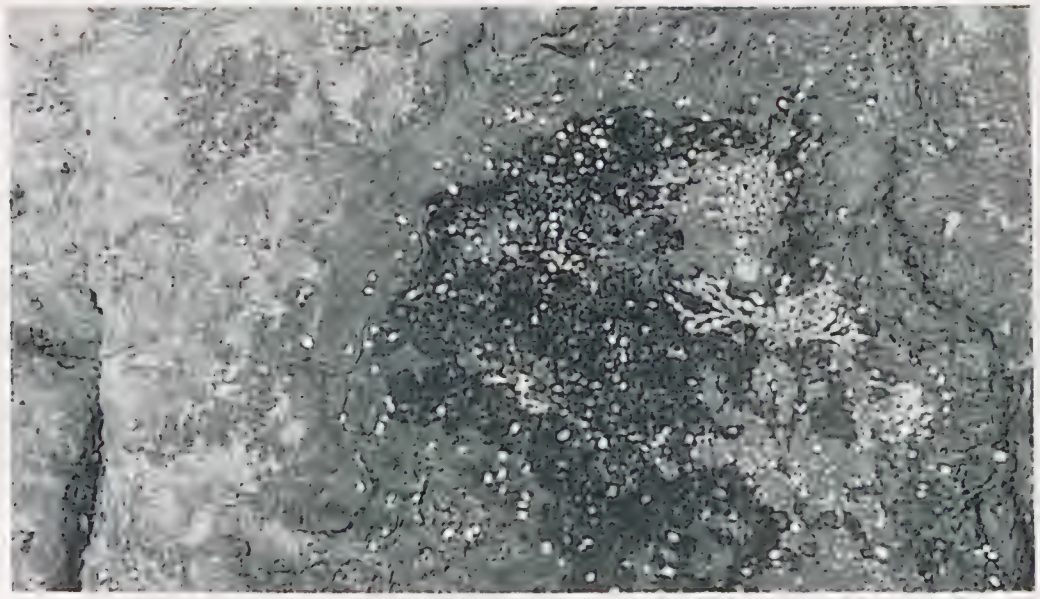

Fig. 1.—Limpet 'homes' on Fossil Island. The dark background is a blue-green alga, ? *Isactis*. The white objects are *Siphonaria diemenensis* with a few *S. zonata* also distinguishable. The grey marks on the algal background are the 'homes' to which the limpets return.

Fig. 2.—*Galeolaria-Brachyodontes* at the reef in Pirates Bay.

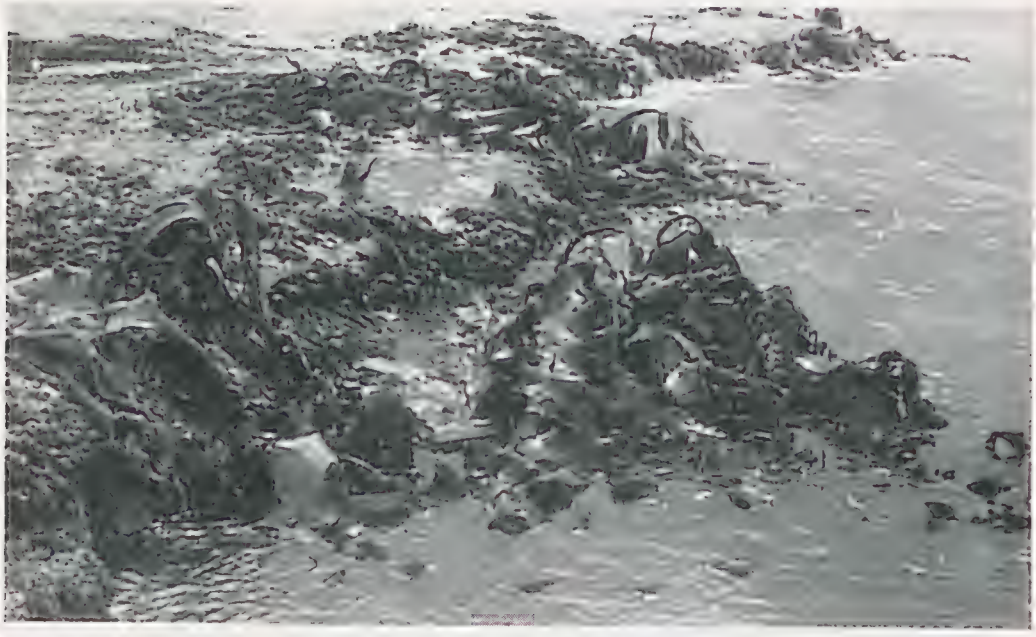

FIG. 1.—*Pyura* and *Sarcophycus* at the end of the reef in Pirates Bay.

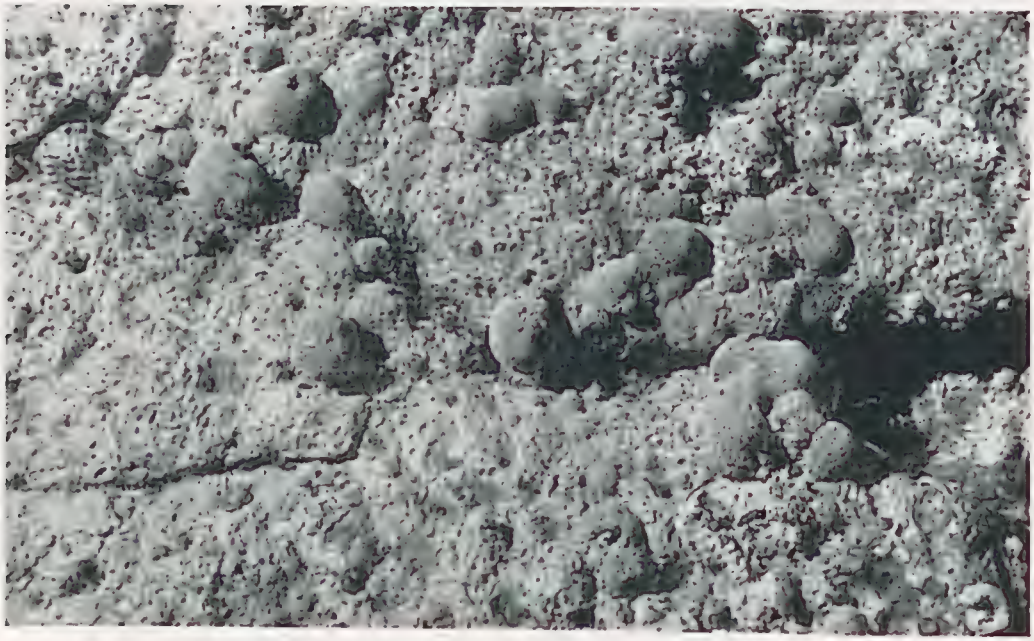

FIG. 2.—*Lithophyllum* at Point Puer, Port Arthur.

FIG. 1.—*Catophragmus polymerus* at Frying Pan Island, Port Arthur.

FIG. 2.—The zonation at Opossum Bay, Port Arthur. The black patches on the rocks are *Lichina*. The *Galeolaria* belt is very thin and is immediately replaced by *Hormosira*.

The Nature of Intertidal Zonation in Tasmania

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Summary

The various types of zonation found on the different coasts of Tasmania are described and compared. The zones to be seen in Tasmania are compared with the zones found on the Mainland of Australia and the terminology used by several authors is also compared. The geographical affinities of the Tasmanian intertidal region are discussed and it is shown that Tasmania lies within the southern region of large brown seaweeds. This region exhibits other very similar ecological features on the continents in which it occurs. Some parts of the coasts of Victoria are ecologically very similar to Tasmanian shores and there are also close similarities with Kangaroo Island.

Introduction

The types of shore which have been described are as follows:—

Oceanic with heavy wave action at Eaglehawk Neck, Sleepy Bay, Remarkable Cave, Point Puer, Betsy Island. (Guiler, 1951*a*, 1951*b*, 1951*c*).

Semi-exposed coast with moderate wave action at Blackman's Bay, Betsy Island and Port Arthur (Guiler, 1950, 1951*c*, 1951*a*).

Sheltered coast with very little wave action at Coles Bay, Barnes Bay, Dover, Oyster Cove, Kettering and Dodges Ferry (Guiler, 1951*a*, 1951*d*).

Lagoon with virtually no wave action at Pipe Clay Lagoon (Guiler, 1951*e*).

All types of zonation are to be found on these different coasts. In some cases there are species which are found both on exposed and sheltered shores. Some of these species are not of very much use as indicator species, but others are found in abundance on one type of coast and can be used as indicators of that type of coast. A few species are found on only one type of shore and are therefore characteristic of such shores. A list of the indicator species and the type of shore on which they are found is given in Table 1.

TABLE I.

Indicator species and the type of shore on which they are to be found.

(a) Characteristic of one type of coast

Sarcophycus potatorum (Labill.) Kutz	Exposed coasts.
Lithophyllum hyperellum Foslie	Exposed coasts.
Jania sps.	Exposed coasts.
Ecklonia radiata (Turn.) S. Ag.	Oceanic sheltered.
Zostera sps.	Sheltered.
Assimania brazieri (Ten.-woods)	Lagoons and semi-lagoons.
Austrocochlea obtusa (Dillwyn)	Sheltered and lagoon.
Cymodocea antarctica	Sheltered.
Anapella cycladea (Lam.)	Lagoons and sheltered.
Bittium lawleyanum Crosse	Lagoons.
Pyrazus diemenensis	Sheltered and Lagoons.

(b) Found on several types of coast but dominant on one shore

Melaraphe unifasciata (Gray)	Most coasts in Tasmania, but its absence is characteristic of sheltered shores.
Bembicium nanum (Lam.)	Semi-exposed and sheltered.
Bembicium melanostoma (Gmelin)	Sheltered and Lagoon.
Pyura praeputialis (Heller)	Sheltered, semi-exposed and exposed.
Xiphophora sps.	Semi-exposed to nearly exposed, but best developed at three-quarters exposed.
Lessonia corrugata Lucas	Semi-exposed to exposed. Best developed on nearly exposed shores.
Cystophora spartioides (Turn.) J. Ag.	Semi-exposed to nearly sheltered. Best developed at a quarter exposed.
Cystophora uvifera (Ag.) J. Ag.	Semi-exposed to sheltered. Best developed on sheltered coasts.
Cystophora torulosa (R. Br.) J. Ag.	Semi-exposed to sheltered. Best developed on sheltered coasts.
Catophragmus polymerus Darwin	Semi-exposed to exposed. Best developed at more than semi-exposure with surf.
Galeolaria caespitosa (Lam.)	Sheltered to semi-exposed. Absent on exposed coasts. Best developed on sheltered shores.
Mytilus planulatus (Lam.)	Semi-exposed to sheltered. Best developed on semi-exposed coasts.
Hormosira banksii (Turn.) Decaisne	Semi-exposed to sheltered. Best developed on sheltered shores.
Brachyodontes rostratus (Dunker)	Exposed to sheltered. Best developed on three-quarters exposed coasts.
Corallina cuvieri Lamour.	Exposed to semi-exposed. Best developed on semi-exposed shores.

(c) Ubiquitous on rock shores

Lichina confinis
Cancer novae-zealandiae Jacquinot & Lucas
Ulva lactuca (L.)
Petrolisthes sp.

It must be noted that the species living in the pool environment are not included in the above. *Melanerita melanotragus* Smith is a very common organism in ponds on the exposed east coast but it is confined to ponds and does not have any value as a zonal organism.

It is proposed to discuss the zones seen in the major divisions of the intertidal region and compare these zones with their equivalents on various types of shore. For reasons outlined in Guiler, 1951*e*, the lagoon will be compared separately with the other types of shore. (Table 2).

EXPOSED									SEMI-EXPOSED								
SLEEPY B. PT. PUER	BETSY IS. W.	BETSY IS. E.	SLEEPY B. V. EXPOSED	FOSSIL IS.		REMARK'LE CAVE	PIRATES' BAY		BLACKMAN'S BAY AREA			OPOSSUM BAY	LADY BAY	FOSSIL IS.	FRYING PAN IS.	N.E BETSY IS	EXPOSURE
BARE LICH.			LICH. BARE														
MEL.	MEL.		MEL.	MEL.		MEL.	MEL.		MEL.			LICHENS + MEL.	LICHEN + MEL.	MEL.		MEL.	70-100 %
BARN.	BARN.		BARN.	BARN.		BARN.	BARN. GAL.+ BRA.		BEMB. BARN. GAL.	BARN. BRA.	BARN.	SIPHO. + TETRA. GAL.	BARN. RIV. GAL.	BARN.	BARN.	? BARN. GAL.	27-88 % 18-70 %
PAT.	CATO. CATO.	PAT	CATO.	PAT. + RIV.	PAT. + ACT.	BRA.	BRA.	BRA.	PAT.	MYT.	MYT.	GAL. + HOR.	GAL. + HOR.	PAT. + HOR.	CATO.+ MYT.	COD. +/or MYT.	7-60 % 0-26 %
COR.		CATO.	COR.	COR. COR.	COR. + ULVA	COR.		LAUR.	MYT. LAUR.		CATO.	HOR. + CYST.		COR.	CATO.		
SAR.	LESS.		SAR.	SAR.	XIP. + SAR.	PYURA + SAR.	PYURA +/or SAR.		LESS.			CYST.	CYST.	CYST.	XIPH.	LESS.	0-2 %

TABLE II.—*continued on next page.*

<table>
<tr><th colspan="10">SHELTERED</th><th colspan="2">LAGOON</th><th colspan="2">TERMINOLOGY</th></tr>
<tr><td>COLES BAY</td><td colspan="3">BARNE'S BAY</td><td>DODGE'S FERRY</td><td>DOVER</td><td>GRANGE</td><td>PT. PUER</td><td>JETTY AT FOSSIL IS.</td><td>KETTERING</td><td>OYSTER COVE</td><td>PIPE CLAY</td><td>LAGOON</td><td>S. & S., 1949.</td></tr>
<tr><td></td><td colspan="3"></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>ARTHROCNEMON</td><td>UPPER SHORE</td><td>SUPRALITT.</td></tr>
<tr><td>MEL.</td><td colspan="3">MEL.</td><td>MEL.</td><td></td><td>MEL.</td><td></td><td>MEL.</td><td>BRA.</td><td>LICH.</td><td>ARTHROCNEMON + SALINATOR</td><td></td><td>S-L. FRINGE</td></tr>
<tr><td rowspan="4">BARN.

GAL.</td><td>BEMB BARN AUST

GAL.</td><td>BARN. AUST.

GAL</td><td rowspan="4">BEMB. AUST OR BARN

GAL + SYP. OR MYT.

GAL + MYT.</td><td rowspan="4">BARN.

GAL.</td><td>BEMB
AUST.</td><td rowspan="4"></td><td rowspan="4">BARN.</td><td rowspan="4">AUST.</td><td rowspan="4">AUST.

GAL. + MYT.</td><td rowspan="4">SIPHO.

GAL.</td><td rowspan="4">BEMB.
BITTIUM
ANAPELLA

(ANTHO.)</td><td rowspan="4">SUPRA

ZOSTERA</td><td rowspan="4">MID

LITTORAL</td></tr>
<tr><td rowspan="2">HOR.</td><td rowspan="2">BRA</td><td rowspan="3">HOR + MYT.</td><td rowspan="3">MYT.</td><td rowspan="3">HOR.</td><td rowspan="3">MYT.</td><td rowspan="3">HOR</td></tr>
<tr><td>PAT.</td></tr>
<tr><td rowspan="2">COR.</td><td rowspan="2">MYT.</td><td rowspan="2">HOR.</td><td>ZOSTERA</td><td>ZOSTERA</td></tr>
<tr><td>COR.</td><td>MIXED</td><td>MARCIA</td><td>INFRA</td></tr>
<tr><td>CYST.</td><td colspan="3">CYST.</td><td>PYURA</td><td>CYST.</td><td>CYST.</td><td>CYST.</td><td>CYST. + ECK.</td><td>CYST.</td><td>CYST.</td><td>AUST.</td><td>ZOSTERA</td><td>INFRALITT. FRINGE</td></tr>
</table>

TABLE II.—Comparison of the zonation seen on various types of coast in Tasmania. These zones are compared with the terminology of Stephenson & Stephenson (1949) and also with the proposed lagoon terminology.

Abbreviations used are: LICH.—Lichens; MEL.—Melaraphe; BARN.—Barnacles; PAT.—Patelloids; COR.—Corallines; SAR.—Sarcophycus; CATO.—*Catophragmus;* LESS.—*Lessonia;* RIV.—*Rivularia;* ACT.—*Actinia;* XIP.—*Xiphophora;* BRA.—*Brachyodontes;* GAL.—*Galcolaria;* LAUR.—*Laurencia;* BEMB.—*Bembicium;* MYT.—*Mytilus;* SIPHO.—*Siphonaria;* TETRA.—*Tetraclita;* HOR.—*Hormosira;* CYST.—*Cystophora;* COD.—*Codium;* SYP.—*Sypharochiton;* AUST.—*Austrocochleia;* ECK.—*Ecklonia.*

The striking feature of the intertidal region in Tasmania is the bareness of most of the shore. This bareness becomes evident very sharply at a level which experiences about 30 per cent exposure. The forms inhabiting the shore below this "Lethal" level according to the different types of coast. Above this lethal level the species are few in number and individuals.

TABLE III

The number of species on the shore at certain levels at six places in Tasmania.

Height R.D. at Blackman's Bay	Sleepy Bay	Coles Bay	Blackman's Bay	Betsy Island	Oyster Cove	Pipe Clay
8′ 6″	24 +	33 +	31 +	?	20 +	17
10′ 6″	10	10	7	9	7	7
11′ 3″	8	7	4	5	5	3

The number of species above the lethal level is fairly uniform on the different types of coast although the species composition may be different. Table III. also shows the very small number of species encountered on the shore, though there is a great difference in the numbers of individuals found on the different types of coast. The upper shore is most bare in appearance on sheltered coasts. Exposed coasts, with one or two exceptions, are very nearly as bare. The exceptions noted are at Betsy Island and Remarkable Cave. The former locality has a very dense growth of *Chthamalus* covering most of the Midlittoral and at Remarkable Cave there is a barnacle—*Brachyodontes* growth over a large area of the Midlittoral. The semi-exposed coasts show the greatest development of intertidal life. Although the number of species is not any greater than on other coasts there are a great many more individuals of these species. As examples, we have the Hormosiretum at Point Puer and the more dense barnacle population at Blackman's Bay. It is not valid to compare the numbers of the fauna of a lagoon with those seen on other types of coast as the lagoon habitat is very specialised, most of the forms occupying a burrowing niche.

On an exposed coast the zones are very much wider than those seen on sheltered shores. This is, of course, a universal feature of the intertidal region.

There is a great difference between the dominant species found on wave exposed coasts and those encountered on sheltered shores. This difference is greater than that noted between the dominant species of semi-exposed and exposed or sheltered coasts. This is only what might be expected. The dominant species on lagoons are entirely different from those found on any rocky shore. As noted previously, ocean surf beaches have not been examined.

(1) *The Supralittoral Zone*

The Supralittoral region is usually bare but in some places, for example, at Pierson's Point and Sleepy Bay, orange and grey lichens form very prominent bands around the shore. These two localities are semi-exposed and exposed coasts respectively but on sheltered shores the Supralittoral is usually bare, with such plants as *Mesembryanthemum* at the upper limits. In lagoons the Supralittoral is occupied by some form of salt marsh or brackish water marsh. At Pipe Clay Lagoon there is an *Arthrocnemon* scrub while at Boomer Marsh there is a

saltings (Curtis & Somerville, 1947). A similar association to that found at Boomer is to be seen at Moulting Lagoon near Freycinet Peninsula.

(2) *The Supralittoral Fringe*

(a) The Melaraphe Belt

This belt is found on all coasts in Tasmania with the exception of very sheltered rocky shores, beaches and lagoons. There is usually one species found in the belt, namely *Melaraphe unifasciata*, though in places where there is intense spray *Melaraphe praetermissa* may also be found in the Supralittoral Fringe. In certain localities another Littorinid, *Bembicium nanum*, is found immediately below the *Melaraphe* belt. At Blackman's Bay *Bembicium* is locally developed into a prominent band, but in places where wave action is strong the species is absent. *Bembicium melanostoma* is found in lagoons and also on some very sheltered shores. The two *Bembicium* species probably represent the upper limit of the Midlittoral. Bearing in mind the accepted Littorinid zone in British waters with *Littorina saxatilis* and *L. neritoides* as the dominant species, it appears that *Littorina neritoides* is represented in Australia by *Melaraphe unifasciata* and *L. saxatilis* by *Nodilittorina tuberculata*. The latter species is absent from Tasmania. The *Bembicium* species probably represent British species which are found further down the shore, perhaps *Littorina littoralis* or *L. littorea*. This hypothesis is substantiated by the occurrence of many *Bembicium* in the Midlittoral and by the presence of the belt dominated by that genus below the barnacles at Dover.

(3) *The Midlittoral Zone*

(a) The Barnacle Belt

The distribution of barnacles in Tasmania will be discussed fully below. It may be noted here that the belt is only rarely well developed and in no sense can be compared to the *Tetraclita rosea* belt on the New South Wales coast. The species are very few both in number and individuals.

The belt is wide spread on the coast of Tasmania. In some places, due to the small numbers of the barnacles, *Siphonaria* replaces them as the dominant organism, for example, at Oyster Cove and locally at Opossum Bay. In places where there is no substratum suitable for barnacle attachment the zone may be absent, for example, at Pipe Clay Lagoon and at the head of Barnes Bay. The shore at Kettering where there is shelter from the sun and little wave action the barnacle belt is replaced by *Austrocochlea* + *Mytilus* and/or *Galeolaria*. Similarly, at the Grange where the reef is below the barnacle level and there is no suitable substratum, the barnacle belt is absent.

(b) Patelloid Belt

On wave exposed coasts the presence of a Patelloid belt below the barnacles is an interesting feature. This belt is characteristic of some shores in South Africa (Bright, 1938*a*) and it is a significant geographical parallel to find a similar feature in Tasmania. Pope (1951*b*) observed that there was a tendency to a Patelloid belt in southern Victoria.

The Patelloid belt is obvious on all coasts having heavy wave exposure. The species composition of the belt is remarkably constant.

Patelloida alticostata, P. conoidea, Cellana limbata, C. variegata, Siphonaria diemenensis and *S. zonata* are the most common species found. In places the Patelloids may have *Rivularia* growing in the same belt. This is seen at Fossil Island and is probably indicative of broken water resulting from surf being formed by boulders, &c. If *Brachyodontes rostratus* is present in sheets covering large areas of rock, the Patelloid belt is eliminiated by the mussels. This condition is seen on the reefs in Pirates Bay and at Remarkable Cave. Blackman's Bay probably represents the minimum wave action required by the Patelloids to permit them to form a belt.

All grades of mixing with other belts are to be seen at different places on this coast. In some areas for example Eaglehawk Neck, the Patelloids become mixed with other species not usually found forming a belt, e.g., *Actinia equina*. The Patelloid belt is absent from sheltered coasts and lagoons, though the individual species that compose the belt may all be found in the more sheltered situations.

In some places where there is heavy surf the Patelloid belt may be suppressed entirely or in its lower parts there may be a well developed *Catophragmus* belt, e.g., on the west side of Betsy Island and Frying Pan Island or on parts of the Blow Hole platform at Eaglehawk Neck and also at Sleepy Bay. *Catophragmus* is best developed where there is constant surf, oceanic water but not intense wave action. The barnacles at Eaglehawk Neck are smaller than those at Frying Pan Island and fewer in numbers.

The west coast of Tasmania has not been examined but I have had the opportunity of examining some photographs taken by Mr. A. Hewer near the Duck River. These show the Patelloid belt extending without a break as far down the shore as the *Sarcophycus*. The suppression of the *Coralline* belt in this region of very heavy surf is most interesting, but detailed examination is necessary before conclusions can be drawn.

On sheltered coasts the Patelloid belt is replaced by *Hormosira*, e.g., Point Puer and Coles Bay. At the area where the change from one species to another takes place, e.g., Fossil Island, the *Hormosira* is found lower down the shore and extends up to replace the Patelloids. *Hormosira* is best developed on sheltered shores and does not grow on exposed places. This is different from the condition at Long Reef, Sydney, where the weed forms a continuous covering to the rocks (Pope, 1943). On exposed or semi-exposed shores the species is confined to the rock pool environment.

In some areas, e.g., North-eastern Betsy Island, *Galeolaria* replaces the Patelloids and at Opossum Bay both *Galeolaria* and *Hormosira* replace the limpets. At Barnes Bay the Patelloid belt is replaced by a *Brachyodontes* belt. This feature theoretically resembles that seen at Pirates Bay but at the latter locality the mussels are in sheets whereas at Barnes Bay they are in thin clusters. In other places *Mytilus planulatus* replaces the Patelloid belt. All combinations of these species can be found on the sheltered coasts, depending on the degree of wave exposure at the place examined.

(c) Corallines

The Coralline belt is also characteristic of exposed coasts. The species composition of the belt is not fully known as the Corallines are a very poorly worked group in Australia.

The Coralline belt includes a *Jania* sp., *Corallina cuvieri*, *C. officinalis* and *Lithophyllum hyperellum*. This latter species is indicative of heavy wave action. It is very poorly developed on Betsy Island. The belt is usually very thickly populated by the calcareous algae and other forms are prevented from successfully colonizing the rocks. The belt is never great in vertical height but at the appropriate tidal levels may be some feet wide on a horizontal shelf. It is absent from the semi-exposed shore at Blackman's Bay and even from some exposed places such as Betsy Island. The belt is well developed on the sheltered side of the Freycinet Peninsula at Coles Bay and also on the sheltered side of Fossil Island, though the coral-like *Lithophyllum* is not present in either of the localities.

The Coralline belt is found on all of the coasts in Tasmania which are washed by oceanic waters. On the eastern shoreline the Corallines are present as a continuous band, irrespective of wave action. At Blackman's Bay there is no Coralline belt. This area does not suffer from any marked degree of fresh water pollution but true oceanic water does not always occur there. The belt appears at Lucas Point, nearer the mouth of the estuary but is absent from Betsy Island. The reason for the absence of the Corallines from Betsy Island is not known.

In sheltered places the Corallines are usually replaced by *Hormosira*, though in the exceptional conditions seen at Kettering and Barnes Bay, *Mytilus* and *Galeolaria* are dominant on most of the shore above the Infralittoral Fringe. The mussels replace the Corallines on semi-exposed coasts, e.g., between Blackman's Bay and Kingston. In places of heavy surf suitable to the growth of *Catophragmus* the barnacle replaced the Corallines. In some places the *Catophragmus* belt extends from the barnacles to the Infralittoral Fringe, e.g., on the western shore of Betsy Island and at Frying Pan Island. The Corallines are absent from lagoons and their place is largely taken by a belt dominated by *Marcia corrugata*.

(d) Galeolaria

This serpulid is found on nearly all types of coast, usually forming a belt on exposed and semi-exposed shores. The species is absent from extremely exposed places but it is found in sheltered clefts on an exposed coast line. The species does not like surf, being absent from Frying Pan Island. The worms are found in lagoons and sheltered places, where they form dense masses on stone on the lower shore.

On exposed shores the *Galeolaria* belt is replaced in part by the *Patelloids* but mostly by a downward extension of the barnacles. If there is heavy surf the *Catophragmus* belt replaces the *Galeolaria*.

Galeolaria frequently forms mixed belts, particularly with mussels. In the sheltered places there are several such mixed belts to be seen, e.g., at Barnes Bay (with *Mytilus planulatus*), at Pirates Bay (with *Brachyodontes rostratus*). Less commonly it is found with *Hormosira* (Lady Bay) or *Sypharochiton pellis-serpentis* (at Barnes Bay).

The worm tubes have been found in various places forming masses up to six inches thick on rocks, e.g., Dodges Ferry. These masses have a dense fauna dwelling within them. In particular the interesting form of the barnacle *Ibla quadrivalvis* has been noted (Guiler, 1951*d*). The

small lamellibranch, *Lasaea australis,* is also extremely plentiful in the tube masses along with numerous species of polychaetes, *Leptolana australis* and isopods and amphipods.

(e) Mytilus planulatus

The beds formed by this species are only found in restricted areas of southern Australia, e.g., the south coast of Victoria (Pope, 1951*a*), but they are a feature of Tasmanian coasts. The species is widespread occurring on all but exposed coasts. The beds are characteristic of semi-exposed places.

On sheltered shores the mussel beds are replaced by *Hormosira.* In places with surf the mussels are found in fairly large numbers, e.g., at Frying Pan Island and Betsy Island, but they are not the dominant species as they are replaced by *Catophragmus.* The mussel beds form an important ecological habitat as large numbers of animals live both on and below the mussels.

The distribution of mussels in Tasmania is discussed below.

(f) Catophragmus polymerus

This barnacle is only dominant where there is heavy surf. *Catophragmus* is present but not dominant in regions where the waves pound directly on the shore, but if the shore is swept by broken water or surf the barnacle is extremely numerous and the individuals are of a large size. The eastern shore of Betsy Island is the outstanding example of this type of coast with a resulting dense *Catophragmus* population. On exposed shores *Catophragmus* is replaced by the *Corallina* belt and on sheltered shores *Hormosira* and *Mytilus* replace the barnacle.

(g) Austrocochlea obtusa

As noted in Guiler, 1951*e* there are three ecological varieties of this species. A strongly ribbed white variety, formerly called *A. constricta,* which is found on exposed coasts on the mainland (Macpherson, 1950), a normal *Austrocochlea obtusa* and a small estuarine form. None of these forms is found on exposed coasts in Tasmania but the ribbed form is most common in sheltered places. The small estuarine variety is found in the hypersaline Pipe Clay Lagoon. The normal variety is found on sheltered shores, and may occur with the var. *constricta.*

(h) Semi-cryptic species

On all coasts there are some species which are confined to cryptic or semi-cryptic places. These species are often found as indicators at a lower level on the shore, being forced to seek sheltered places at levels higher than that at which they experience their optimum exposure. The chiton, *Sypharochiton pellis-serpentis,* is often found in cracks in rocks in the barnacle belt but is not found as a dominant. In some restricted sheltered areas it achieves a co-dominance, living in exceptionally large numbers among the dominant species, the latter forming a shelter necessary for the chiton. The barnacle *Chthamalus antennatus* is also found in a semi-cryptic habitat at a higher level on the shore than is usual for the species. It does not form a zonal band at the higher level, the dominant species at this level being *Melaraphe unifasciata.*

Lagoon Conditions

The fauna of a lagoon differs very considerably from that found on any other type of shore in Tasmania. Not only are the dominant species different from those on more exposed coasts but the majority of the animals found in the lagoon are also different. A few species, e.g., *Elminius modestus* are found in lagoons as well as on other types of shore. These species are of great value for correlating tidal levels and are listed in Table IV.

Table IV

Species which are found in Pipe Clay Lagoon as well as on other types of coast.

SPECIES	ALSO FOUND ON
Brachyodontes rostratus	Sheltered to exposed coasts.
Mytilus planulatus	Semi-exposed to sheltered coasts.
Pyura praeputialis	Sheltered to nearly exposed coasts.
Elminius modestus	Semi-exposed to sheltered coasts.
Bembicium melanostoma	Sheltered coasts.
Patelloida conoidea	Rocky coasts.

Some species such as *Mictyris platycheles* do not form suitable indicators for comparing faunal levels on different types of shore as they are of a roving habit. This species is found on several surf beaches as well as in the lagoon.

The upper shore of the lagoon is composed of two parts, the *Arthrocnemon* scrub and *Arthrocnemon* with *Salinator*. The *Arthrocnemon* scrub is represented on more exposed coasts by either a lichen belt or bare rock. Where *Salinator* is present the scrub is the equivalent of the *Melaraphe* belt, i.e., it forms the Supralittoral Fringe. The presence of *Bembicium* in the belt below that jointly occupied by *Arthrocnemon* and *Salinator* is the indicator which make it possible to correlate the Supralittoral Fringe and the Midlittoral of rocky shores with the lagoon. On rocky coasts *Bembicium* follows immediately below the *Melaraphe* belt and forms the top strip of the Midlittoral zone.

The barnacle belt is absent from lagoons and is replaced by the gastropod-lamellibranch belts of the Supra Zostera zone. The *Bembicium* and *Bittium* belts cover a smaller area of the shore than the *Anapella* belt, the latter species being dominant over most of the Supra Zostera Zone.

The *Bembicium melanostoma* belt of the lagoon is represented on sheltered coasts by the belt occupied by *Bembicium nanum*. Some doubt exists as to the validity of these two species. It is probable that the two species are ecological varieties as specimens of *B. nanum* found at Dover are very similar to small individuals of *B. melanostoma*. On semi-exposed and exposed coasts the *Bembicium* belt is absent and is represented by the barnacle belt or by *Siphonaria* (e.g., at Opossum Bay and Port Arthur).

The *Bittium* belt is represented on semi-exposed or exposed coasts by a part of the barnacle belt. The *Anapella* belt is the widest belt found on the shore and is represented on semi-exposed coasts by the *Galeolaria, Brachyodontes, Hormosira* and part of the *Mytilus* belt. On exposed coasts it is represented by the *Patelloid* and *Catophragmus* belts.

The lamellibranchs are found burrowing in the immediate sub-surface sand. In the upper part of the *Anapella* belt the lamellibranchs are not utilised as a substratum by the anemone *Anthopleura aureo-radiata,* but in the lower part of the belt the anemone attaches itself to many of the lamellibranchs. Although there may be as many as twenty anemones per square foot, the lamellibranchs are still the dominant species as they number as many as 35 per square foot in the same part of the lagoon. It is possible to consider the *Anthopleura* as forming a sub-belt in the *Anapella* belt at about the same level as would be occupied on other types of coast by *Brachyodontes, Hormosira* and Patelloids.

The Zostera beds are found at three different tidal levels on the lagoon. The beds Z_1, Z_2, and Z_5 all occur at the level which approximates to that occupied by *Mytilus planulatus* on semi-exposed coasts. (Guiler, 1951*a*). This species is found in the lagoon and is common in the *Zostera* beds. The *Zostera* at Z_3 and Z_4 is found at a higher level on the shore than at any other place. As noted earlier these two latter beds are found at a higher level on account of the effect of the wind. The level at which *Zostera* occurs can also be shown by direct observation of tidal levels to be about the same as that of the upper *Mytilus* belt. A ' low high ' tide just exposes the *Zostera* in the lagoon and also just exposes the mussel beds at Blackman's Bay.

The belt occupied by *Marcia corrugata* corresponds to that occupied by the lower part of the mussel beds, *Catophragmus* or the *Corallines.* A few clusters of *Mytilus* are found in this belt and are useful species for the correlation of faunal levels on the different types of shore.

The Infralittoral Fringe is represented by a belt dominated by *Austrocochlea obtusa* var. *constricta.* This species occurs over most of the lagoon shore but is dominant only on the lower parts of the intertidal region. The species is also found at various levels on rocky shores but does not form a belt at such a lower tidal level as at Pipe Clay Lagoon. A possible reason for this is to be found in the density of algal population on rocky coasts. The seaweeds of the Infralittoral Fringe on coasts which experience oceanic water are particularly well developed.

The Infralittoral is dominated by clusters of *Pyura, Mytilus, Ostrea* and several smaller species. The majority of the *Pyura* clusters are never exposed at low water. A few clusters of the ascidians are exposed but these are small in size and have been moved by wind and waves to a higher level than normal. In Barnes Bay there are similar Infralittoral clusters of *Pyura.*

(4) *The Infralittoral Fringe*

The very sharp change in dominant takes place in the Infralittoral Fringe. In practically all of the places visited the dominant forms on this part of the shore are algae. The exceptions are *Pyura* at Dodges Ferry, *Pyura* and *Mytilus* at Barnes Bay, *Sarcophycus* and *Pyura* at Pirates Bay and *Austrocochlea* at Pipe Clay Lagoon.

The salient feature of the Infralittoral Fringe of wave exposed coasts is the presence of the bull-kelp, *Sarcophycus potatorum.* Due to the prevalent swell encountered on these coasts this species is always to be seen, irrespective of the state of the tide. It does not form a habitat for other large organisms. Some hydroids, *Spirorbis* sp. and other small organisms are occasionally found on the kelp. The holdfast is a large

sucker-like structure and it does not lend itself to the activities of errant polychaetes, molluscs, ascidians and bryozoans as do the holdfasts of *Macrocystis* or *Laminaria*. There is no mollusc filling the niche occupied by *Patina pellucida* (L.) on British coasts. The continual thrashing of the fronds of the weed does not permit dense hydroid or bryzoan growths.

The strap-like algae are a feature of all grades of exposure with the exception of sheltered and lagoon shores. *Phyllosphora, Lessonia, Xiphophora billardieri* and *X. chondrophylla* and *Sarcophycus* are all species with straplike fronds and the presence of any of these species is indicative of fairly strong wave action. The sheltered coasts are characterised by the presence of the less robust species. These species are also smaller in size than the strap-like algae but this is not a general rule. The brown algae of sheltered coasts are usually either of the genera *Cystophora, Hormosira* or *Sargassum* and are frequently accompanied by the green *Caulerpa* sps.

The normal habitat of these algae is the Infralittoral Fringe. Some of these species are found higher up the shore when the wave action is above their optimum (e.g., *Hormosira* and *Lessonia* at the northern end of Fossil Island at Eaglehawk Neck). Species such as *Sarcophycus* which favour the most intense wave action are not found further up the shore than the Infralittoral Fringe.

When the wave action is below the optimum required for a species, there are two possible effects on the algal composition of the Infralittoral Fringe. The species seeks deeper water, i.e., it inhabits the immediate Infralittoral zone, or if the wave action continues to decrease, the species becomes absent from that coast. Due to the topography of Tasmanian coasts this change usually takes place within a very short distance. Between Blackman's Bay and The Grange the exposure is just below the optimum required for *Lessonia* to thrive in the Infralittoral Fringe and this alga is found in the Infralittoral zone immediately below the Infralittoral Fringe.

It is possible that in many cases the retreat into deeper water is prevented by the usually dense growth of Infralittoral forms. At the best the Infralittoral is only a substitute habitat for Infralittoral Fringe algae and the species, which are indigenous to the former habitat and maintain a permanent breeding stock in it, will certainly dominate the environment. The result of this is that the algae of the Infralittoral Fringe will only be able to find occasional opportunities for retreat into deeper water.

In other places the nature of the substratum may change at or below the level of ' low low ' water. If the change of the substratum is very marked profound floral and faunal changes will also take place. In sheltered bays, such as Oyster Cove, the rocks of the intertidal region are suddenly replaced at ' low low ' water by a sandy mud. This results in an immediate biological change. The algae are eliminated and replaced by *Zostera* (on the eastern seaboard there is also *Cymodocea*) and the fauna becomes either fossorial in nature or is confined to mollusc or ascidian clusters. In such an area the Infralittoral Fringe is extremely well defined.

There is a third type of alga found in the Infralittoral Fringe. The two types discussed above are the species which are characteristic of the Fringe at the wave action experienced in that area and the species

that may have retreated into deeper water because of diminishing wave action. The third type is the species which is reaching the end of its geographical range and is found in deeper and/or more sheltered water than its normal habitat. Such a species is *Ecklonia radiata*. This species is very plentiful in New South Wales on exposed coasts in the Infralittoral Fringe (Dakin, Bennett and Pope, 1948). In Tasmania the species is rare and is found in places where it is only partially exposed (if at all) at low water and where the wave action is slight, e.g., Lady Bay and the Old Jetty at Fossil Island. Pope (1951*a*) found a similar distribution for this species on the Victorian coast but with the exception that the species did not favour such sheltered places. Pope (1951*b*) pointed out that the distribution of *Ecklonia* in Tasmania was exactly what might have been expected in view of Victorian conditions.

The dominant algae of the Infralittoral Fringe may be summarised in terms of decreasing wave action as *Sarcophycus, Phyllospora, Lessonia, Xiphophora* sps., *Cystophora spartioides, C. torulosa, C. uvifera* with local *Caulerpa brownii*. *Hormosira* may be dominant in the Infralittoral in restricted areas but it is more usually characteristic of the lower Midlittoral. If dominant in the Infralittoral Fringe it has a wave action toleration about the same as that of *Cystophora torulosa*. Eaglehawk Neck is the most important area for algal zonation as controlled by wave action, the algae being arranged in the series as listed above.

(5) *The Infralittoral*

No attempts have been made to systematically examine the Infralittoral region. In certain areas the Infralittoral has been examined as far as possible at low tide either by wading or from a boat. The purpose of these examinations was to ascertain if there was any significant difference between the Infralittoral and the Infralittoral Fringe.

At Coles Bay the Infralittoral is composed of the same dominant algal species as the Infralittoral Fringe, but there is a great difference in the fauna of the two zones. Intensive collection in the Infralittoral Fringe failed to reveal as many forms as were collected or observed in the Infralittoral. No examination of the Infralittoral was possible on wave-exposed coasts. The difference between the Infralittoral and the Infralittoral Fringe in sheltered bays has been noted above where *Zostera* replaces the *Cystophoras* on the muddy bay bottom. On a sandy bottom the *Zostera* is frequently replaced by *Cymodocea*. Although no detailed examinations have been undertaken it is possible to state that there is a very pronounced faunal, and often floral, change between the Infralittoral Fringe and the Infralittoral.

Discussion

On the shores of Tasmania, as in all other parts of the world, there is a definite vertical zonation of the dominant species. Animals are usually dominant over all types of the coast but at the Infralittoral Fringe a very sharp change occurs and algae become the dominant species. The algae are of more use than the animals as wave exposure indicators. The presence of *Zostera* indicates lagoon or very sheltered conditions.

It is possible to estimate the relative degree of wave exposure experienced on any coast by the forms found on that shore, especially by the algae of the Infralittoral Fringe. The animals of the Midlittoral may be confusing in this respect as one species may be found on several types of shore. The Infralittoral Fringe algae are characteristic and in terms of decreasing wave action the species are *Sarcophycus, Phyllospora, Xiphophora, Cystophora spartioides, Cystophora torulosa, C. uvifera* and finally in very sheltered places the phanerogam, *Zostera.*

Comparison of Tasmanian Intertidal Features With Those seen on the Mainland

Literature describing the intertidal features on the southern and eastern coasts of Australia has been reviewed in Guiler, 1950. The principal descriptive works are those of Hedley (1915), Pope (1943), Dakin, Bennett and Pope, 1948, all dealing with New South Wales. Two papers by Womersley (1947, 1948), describe the features of the algal ecology of Kangaroo Island in South Australia and Edmonds (1948) describes the animal ecology of the same island. Fischer (1940) gives a comparative account of the littoral animals of Australia as a whole.

It is possible only to compare the exposed rocky coasts as other types of shore on the Mainland have not been fully described. The pool habitat has not been considered in Tasmania. Due to the lack of tidal data from other parts of Australia it is not possible to compare the exposure suffered by intertidal organisms in Tasmania with similar data for the same species on the Mainland.

It is proposed to consider each zone in Tasmania and its equivalent on the Mainland and then to draw an overall comparison between the shores of Tasmania and those of Australia.

The Supralittoral Zone

The Supralittoral in Tasmania is either bare or occupied by lichens. Pope (1943) and Dakin, Bennett and Pope (1948) do not mention the presence of lichens on the New South Wales coast but these plants are to be found on exposed coasts in that State. Edmonds (1948) records a *Lichina* sp. from Kangaroo Island. The common Tasmanian lichens found in this belt are a bright orange coloured *Telostichistes parietinus* (L.) Norm., and orange *Candelariella vitellina* (Ehrn.) Müll. and a white *Lecanora* sp. I am indebted to Mr. Cribb of the University of Queensland for this information. No work has yet been attempted on the distribution of the Tasmanian lichens.

The Supralittoral Fringe

There are two species found in this belt in Tasmania. These are *Melaraphe unifasciata* and *M. praetermissa.* Of these two species *M. praetermissa* is found at lower levels than *M. unifasciata,* though at one restricted area near Roaring Beach, Dover, the small *M. praetermissa* occurs above the larger *M. unifasciata.*

On the coast of New South Wales the Supralittoral Fringe is occupied by *Nodilittorina tuberculata* (Menke), *Melaraphe unifasciata, Melanerita melanotragus* (Smith) and *Notoacmaea petterdi* (Ten.-Woods). *Nodilittorina* and *Notoacmaea* do not occur in Tasmania. *Melanerita* is found in rock pools on the east coast, particularly in the northern parts. It is

also found on the north coast where it is more generally distributed than on the east coast. The crabs found in this belt on the New South Wales coast are the same as those found in Tasmania, namely *Cyclograpsus audouinii* (M-Edw.) and *Leptograpsus variegatus* (Fabr.). Both from the literature and from personal observations at Harbord, Vaucluse and Long Reef, the Supralittoral Fringe in New South Wales is very similar to that seen in Tasmania with the exception of the absence of *Nodilittorina* and *Notoacmaea* from the latter place. Pope (1943) observes that most of the Supralittoral Fringe species inhabit cracks and so there is little apparent difference between the upper shore of the Sydney region and that of Tasmania. On a cursory examination the Supralittoral Fringe of both countries appears to be very poorly populated by *Melaraphe unifasciata*.

In South Australia the Supralittoral Fringe bears a very close resemblance to Tasmanian conditions. Edmonds found *Melaraphe unifasciata* and *Ligia australiensis* at Kangaroo Island, while Womersley found a well developed winter growth of *Prasiola* at the same place. This algal growth is well developed in places where there are penguin tracks. I have not found any Tasmanian algae living as high on the shore. Apart from this local algal growth the Supralittoral Fringe in South Australia is very similar, if not identical to the same zone in Tasmania.

The Midlittoral Zone

(a) Barnacles

The barnacle belt in Tasmania is not at all well developed. It is populated by five species of barnacle, namely, *Elminius modestus* Darwin *Elminius simplex* Darwin, *Chthamalus antennatus* Darwin, *Chamaesipho columna* (Spengler) and rarely, *Tetraclita purpurascens* (Wood). These barnacles are not all found living on the same type of coast. Also found in the belt are *Bembicium nanum* Lam. and/or *B. melanostoma* (Gmelin), *Austrocochlea obtusa* (Dillwyn), *Lichina officinalis, Verrucaria microsporoides* Nyl. and *Lasaea australis* Lam. In local areas *Actinia tenebrosa* (Farq.) and *Austrocochlea concamerata* also occur in this belt.

In New South Wales the belt is populated by eleven species of barnacles, namely, *Tetraclita rosea* Darwin, *T. purpurascens, Chamaesipho columna, Chthamalus antennatus, Elminius modestus, E. simplex, Balanus amphitrite, B. imperator* Darwin, *B. nigrescens* Lam., *B. algicola* Pilsbry and *Catophragmus polymerus* Darwin. The latter four species are found on lower parts of the shore and do not reach the upper Midlittoral. Associated with these species are numerous gastropods, a few lamellibranchs, and some echinoderms. The density of population of the Sydney barnacle belt is uniformly greater than that seen in Tasmania with the possible exception of Betsy Island.

In Tasmania, *Hormosira* is the dominant alga of the Midlittoral. At certain seasons of the year other species may appear on the shore, but these evanescent growths are usually of short duration. The genera involved are *Porphyra, Ulva* and *Scytosiphon* (Guiler, MS.). *Hormosira* is nearly always found in rock pools and does not form a complete covering over the shore except in restricted localities such as Point Puer. This is in contrast to the well developed growth of *Hormosira* at Long Reef described by Pope (1943). Both Womersley and Edmonds note the well

developed growth of *Hormosira* at Kangaroo Island. The latter locality shows very well developed Midlittoral algae, Womersley describing thirteen associations in the Littoral zone. From the descriptions and photographs made by these authors Edmonds describes Patelloid and mussel zones below the barnacles.

(b) Galeolaria

The *Galeolaria* belt is found throughout the temperate Eastern seaboard of Australia. Fischer (1940*b*) notes that this zone at Sydney is comparable with that of Hobart, but with population differences. *Galeolaria* is also prominent on certain parts of Kangaroo Island (Edmonds, 1948). Dakin, Bennett and Pope give a list of species closely associated with the *Galeolaria* encrustations. This list is of interest as so few of the species recorded are found in the Tasmanian worm masses. *Actinia tenebrosa* is found in New South Wales near the *Galeolaria* tubes but in Tasmania this species is not found in the *Galeolaria* belt. *Ibla quadrivalvis* and *Lasaea australis* are found both in Tasmania and New South Wales. *Ibla* forms an interesting variety in thick worm tube masses in Tasmania. The serpulid is frequently found forming an encrustation six inches thick on the rocks. The barnacles, which must have settled at about the same time as the worm larvae, have developed a very long peduncle to enable them to feed and successfully survive among the worm tubes.

In South Australia the *Galeolaria* belt is well developed. Edmonds notes that the species is most plentiful on the sheltered shores of Kangaroo Island. This is in full agreement with the distribution of the species in Tasmania.

(c) The Patelloid Belt

This belt is found on exposed coasts and is one of the features of the Tasmanian region. Pope (1951*b*) found an indication of the presence of a Patelloid belt in the Wilson's Promontory area of Victoria. In New South Wales this belt is possibly represented by the upper part of the Infralittoral Fringe. The lower band is characterised by a *Pyura* with *Ecklonia* and *Phyllospora* and has a smaller algae such as *Sargassum, Colpomenia* and *Padina*. Living in the *Pyura* belt are some Patelloid molluscs, e.g., *Patelloida angasi, Montfortula conoidea* (Reeve), *Patellanax squamifera, P. perplexa* and *Cellana tramoserica*. The first named of these species is common in Tasmania, although it is usually higher on the shore than the ascidian but it also extends as far down the shore as the Infralittoral Fringe. The presence of a *Cellana* sp. and three other Patelloids in the *Pyura* belt, is an indication that the upper *Pyura* belt of New South Wales is the equivalent of the Patelloid belt in Tasmania. There is stronger evidence that the New South Wales equivalent of the Patelloid belt is found higher than *Pyura* because of the presence of a *Sargassum-Colpomenia Padina* band. This band is probably the equivalent of the Tasmanian *Laurencia* belt which is found below the Patelloids at the lower limit of the Midlittoral. It is probable that the Patelloid belt of Tasmanian coasts is not replaced by a well defined belt in New South Wales but is represented by an extension of the lower part of the *Galeolaria* belt, which is much wider in New South Wales than in Tasmania.

Edmonds (1948) describes a *Notoacmaea-Siphonaria* band below the barnacle band at Kangaroo Island.

The species composition of the South Australian band is different from that of the Tasmanian Patelloid belt, *Siphonaria diemenensis* being the only species common to both coasts.

From personal observations in Queensland it seems as if the Patelloid belt is replaced by an oyster-barnacle belt.

New South Wales		Queensland.	S. Australia.	S. Tasmania.	Universal.
Hedley, 1915.	D., B. & P., 1948.	Johnston, 1917.	Edmonds, 1948.	Guiler, 1949.	S. & S. 1949.
Upper Zone with Tectarius Chthamalus Melaraphe Tetraclita.	Supralitt. with Melaraphe	Tectarius & Upper Melaraphe Zones.	Supralitt. with Melaraphe.	Supralitt. Fringe with Melaraphe.	Supralitt. Fringe with Littorinids.
Median Zone with Galeolaria.	Upperlitt. with Barnacles Midlitt. with Galeolaria	Lower Mel. or Chthamalus. / Tetraclita.	Barnacles. / Molluscs & Galeolaria.	Barnacles. / Galeolaria Patelloid. Mytilus.	Mid. Littoral.
Lower Zone with Cynthia.	Litt.-Sublitt. Fringe with Pyura.	Sargassum.	Sublitt. Fringe with Cystophora.	Infralitt. Fringe with Laurencia &c.	Infralitt. Fringe with Laminaria &c.

FIG. 1.—The relation of intertidal zones recognised by Australian authors to those proposed by Stephenson & Stephenson (1949). (From Guiler, 1950). The abbreviations used are INFRALITT. Infralittoral; LITT. SUBLITT. Littoral sublittoral Fringe; MEL. Melaraphe; SUPRALITT. Supralittoral; UPPERLITT. Upperlittoral. Fischer (1940) followed the classification of Hedley.

(d) The mussel beds

Mussel beds are found forming extensive sheets on semi-exposed coasts. The beds are formed of one or two species but only one of the species is dominant on the shore at one tidal level. *Brachyodontes rostratus* is dominant on higher parts of the shore and also on more exposed coasts while *Mytilus planulatus* is dominant on semi-exposed or sheltered shores. As noted above, the mussel beds are a feature of the Tasmanian coast. The Wilson's Promontory area of Victoria is very similar to Tasmanian shores as mussel beds are found on the coast around the Promontory.

Mussel beds occur in sheltered parts of Sydney harbour but, according to Hedley (1915), they do not form an important feature of the intertidal region.

Edmonds describes the *Brachyodontes rostratus* band at Kangaroo Island. It is found immediately above the *Hormosira-Actinia* band. Although the latter combination of species does not occur in Tasmania it can be seen from Table II. that such a faunal level would correspond to that occupied by *Brachyodontes* at Blackman's Bay. (In his paper, Edmonds refers to the mussels as *Modiolus pulex* (p. 171), but in a footnote he states that this is probably *B. rostratus*.).

(e) Sarcophycus

This seaweed is found in the lowest part of the Tasmanian intertidal region. The species also occurs on the southern coasts of New South Wales where it joins the *Ecklonia-Phyllospora* association. It is also found in Victoria. *Sarcophycus* reaches its maximum development in Tasmania. On Macquarie Island, which lies 600 miles to the south of

Tasmania, there is a very similar band but the alga is *Durvillea antartica* (Cham.) Hariot. (Kenny, 1951). This latter species is rare in Tasmania, the only records being from drift weed found at high water mark.

In New South Wales the *Ecklonia-Phyllospora* association of Dakin, Bennett and Pope is the equivalent of *Sarcophycus* in Tasmania. In sheltered places in Tasmania *Sarcophycus* is replaced by *Cystophora* and *Sargassum* sps. These two genera are found in similar situations in New South Wales. In South Australia the Infralittoral Fringe, occupied by *Ecklonia, Cystophora* and *Sargassum* closely resembles that of New South Wales.

General Discussion

It is not possible to take a detailed comparison of all the zones found on Tasmanian shores with their equivalent zones on the Mainland. In most cases the workers on the Mainland have either confined their efforts to exposed coasts or they have examined very small areas and given brief notes on the zoning encountered in these places. It is possible to draw certain general conclusions about the comparative appearance of the shores of Tasmania and those of Australia. The major zones on exposed coasts in various parts of the Mainland and Tasmania are shown in Fig. 1.

(a) Queensland

There is very little information available from Queensland. The Queensland coasts can be divided into the coral reef areas and the semi-tropical areas of southern Queensland. The latter may have a zoanthid fauna and when they have been fully investigated it is probable that there will be a close similarity between the zones seen on these shores and those seen on the coasts of Natal as described by Eyre & Stephenson (1938).

The mangrove swamps of Queensland are not represented in Tasmania. There is no similar formation, with the possible exception of *Melaleuca* on some brackish water streams. The fauna of mangroves, as described by Fischer (1940*b*), is similar to that of the Supralittoral Fringe in Tasmania and species which are normally found living on rocks are to be found living on the roots, &c., of mangroves, e.g., *Bembicium melanostoma*. On a tropical rocky coast the species found living above the oysters are similar in appearance to species found on a similar shore in Tasmania. The fauna is composed of barnacles and littorinids. The species composition of the barnacle belt in Queensland is different from that in Tasmania, though some species are the same in both places. One interesting feature is that a considerable part of the shore is bare in both places, the fauna of the barnacle belt being largely confined to cracks in both places.

The oyster band, which forms a prominent feature of the coasts of Queensland, probably represents the *Galeolaria* belt in Tasmania. The oysters, *Ostrea mordax*, are found on semi-exposed and sheltered coasts and are visible from a considerable distance off-shore as a white band. Below the oyster band is a thin strip of large barnacles and oysters, e.g., on West Molle Island, and this is followed by a bare belt which often has a deposit of mud and silt on it. The muddy area continues as far down the shore as the lowest part of the Midlittoral. This latter area is

occupied by the Alcyonarians, *Sarcophytum* sp. and *Lobophytum* sp. (? *palmatum*). The hard corals follow below the Alcyonarians and extend far down into the Infralittoral Region. The upper part of the hard coral belt is exposed at low tides, especially at springs and thus forms the Infralittoral Fringe. The species composition of the Infralittoral Fringe differs from that of the Infralittoral mainly in the absence of the typical 'stags horn' from the former zone. On a sheltered shore the barnacle belt is often absent and is replaced by a muddy shore with coral fragments and *Halimeda*. This in turn is replaced by a *Favia* belt which is above the Alcyonarian band. The *Favia* band corresponds to the lower parts of the Midlittoral in Tasmania, possibly the Patelloid belt. The Alcyonarian band corresponds to the mussel beds in Tasmania. Due to the greater tidal range in Queensland all the belts on the shore are wider than in Tasmania. This feature is especially noticeable in the Infralittoral Fringe where the corals form a strip up to 20 yards or more in width from the Alcyonarian belt. This is of course partly a feature of the reef forming corals which build up colonies from the substratum and only stop this growth when killed by excess exposure to the air.

It is interesting to note that animals are dominant over nearly all of a rocky shore in tropical Queensland, with the exception of a *Halimeda* belt on sheltered, muddy shores.

In semi-temperate Queensland, Johnston (1917) recognised at Caloundra Upper *Melaraphe, Chthamalus, Tetraclita rosea-Liolophasa* and *Sargassum-Ornithochiton zones*. This follows fairly closely the type of zonation found in New South Wales. The two upper zones resemble Tasmanian conditions but the lower parts of the shore have a closer affinity with New South Wales than Tasmania. In sheltered bays, e.g., Moreton Bay, the zoning is very similar to what might be encountered on a similar shore in Tasmania, i.e., *Melaraphe, Bembicium,* barnacles. There is frequently a *Nodilittorina* band above the *Melaraphe*. The lower parts of the shore are muddy, e.g., at Manly, and there is a tendency for lagoon conditions to appear with species such as *Zostera* and *Mictyris longicarpus*. The latter species frequents muddier places in Queensland than the Tasmanian *M. platycheles*.

On exposed coasts in semi-temperate Queensland, e.g., near Coolangatta, the shore superficially resembles Tasmanian conditions but the species composition is very different. The algae of the Infralittoral Fringe are mainly *Sargassum sps*. A Coralline band is well developed but is composed of encrusting *Lithothamnion*-like species. The *Jania* sps. are not as evident as in Tasmania, though this may be a matter of relative wave exposure.

In conclusion it can be said that the coastal conditions of Queensland do not resemble very closely those seen in Tasmania. In coral areas the shore at and below the oyster belt is very different from any shore to be seen in Tasmania. Oysters, Alcyonarians and hard corals replacing the *Galeolaria,* Patelloid, mussel and algal belts of Tasmania.

Temperate exposed coasts show a similarity of zones but the species composition is different. The degree of wave action experienced on the coasts of Queensland not protected by the Barrier Reef is probably greater than that encountered in any part of Tasmania with the exception of the West Coast.

The only resemblance between Tasmanian coasts and those of Queensland lies in the fauna of the upper part of the shore. The barnacle and littorinid belts show a marked similarity, if not in species at least in appearance and general poverty of population. Some Tasmanian species are found in the upper part of the shore in Queensland, e.g., *Melaraphe unifasciata, Bembicium melanostoma* and *Chthamalus antennatus*. Barnacle and littorinid zones are found on nearly all types of coast found in both States with the exception of very sheltered places in Tasmania. Mangrove swamps are absent from Tasmania but the amphibious element of the mangrove fauna corresponds to the fauna of the Supralittoral Fringe in Tasmania.

(b) New South Wales

The upper parts of the shore resemble the conditions seen in Tasmania. The fauna is poor in numbers and is dominated by Littorinids. *Nodilittorina tuberculata* forms a band above *Melaraphe unifasciata*. The former species is absent from Tasmania.

The exposed coasts of New South Wales differ very considerably from those of Tasmania. The salient feature of the New South Wales coast is the wealth of the barnacle fauna. Although there are not many more species than in Tasmania the density of population is very much greater, particularly in places with extreme wave exposure. Betsy Island is the only Tasmanian locality in which the numbers of the barnacle fauna compare favourably with the conditions seen in New South Wales, though on Betsy Island there is only one species forming a dense covering to the above. The species is *Chamaesipho columna*. In New South Wales there are 9 common species of barnacle, namely, *Tetraclita purpurascens, T. rosea, Chthamalus antennatus, Chamaesipho columna, Catophragmus polymerus, Elminius simplex, Balanus nigrescens, B. imperator* and *B. algicola*. The three last named species are largely restricted to the Infralittoral Fringe. In Tasmania there are only five species on wave exposed coasts, namely, *Catophragmus polymerus, Chthamalus antennatus, Chamaesipho columna, Elminius simplex* and *Tetraclita purpurascens. Elminius modestus* and *E. simplex* usually prefer more sheltered conditions. *Balanus trigonus* is rare in Tasmania. When it occurs, it is usually in the Infralittoral Fringe. If we compare the density of population of a species in Tasmania with that of the same species in New South Wales, it is seen that only *Catophragmus polymerus* reaches a similar density in both States. In this connection it is interesting to compare the plates of Dakin with those in my earlier papers on Tasmanian ecology.

The lower Midlittoral of a sheltered coast in New South Wales usually has a very well developed oyster band. This feature is absent from Tasmanian shores. Mangroves are found in estuaries in New South Wales but they are absent from Tasmania.

There is a very interesting inversion of two of the zones in New South Wales and Tasmania. In Tasmania *Galeolaria* occurs above the *Catophragmus* belt, but in New South Wales the reverse is true. The only possible reason offered for this alteration of habitat is that as the barnacle is approaching the end of its geographical range, it is forced to seek a less rigorous environment. *Catophragmus* being the relic of a

tropical fauna (Fischer, 1940) would have to seek less exposure in order to be able to survive the cold of the winter nights to which it is exposed (Guiler, 1950).

The *Galeolaria* belt reaches its best development on sheltered coasts in both States. It is absent from exposed coasts in Tasmania but Dakin, Bennett & Pope describe the species as occurring on exposed shores in New South Wales. Conversation with Miss Pope revealed that their description of an exposed position would correspond to my description of an area with modified exposure. In spite of this difference in nomenclature it is obvious that the worm colonies in New South Wales reach a better degree of development in more exposed places than in Tasmania. In Tasmania the worm colonies are best developed on sheltered coasts where the incrustations are often up to 6 inches in thickness. In New South Wales these incrustations are found in more exposed places, e.g., Merewether. The greater exposure at Merewether is illustrated by a comparison of Dakin, Bennett & Pope, Plate V, Figure 2 (1948) with Plate I of Guiler 1951*d*. The formation and density of population of the worm tubes is remarkably similar in both places.

There is no Patelloid belt in New South Wales.

In many places in New South Wales the dominant form in the Infralittoral Fringe is *Pyura*. *Ecklonia* is dominant in other places with *Sarcophycus* appearing near the southern border of that State. In Tasmania *Pyura* is only rarely dominant being replaced by the *Coralline* and *Sarcophycus* belts. *Pyura* does not form a prominent feature of the shores of Tasmania. In places where the species is dominant it is usually found forming a series of clusters around the holdfast of *Sarcophycus*. The latter species forms the obvious feature of the shore.

It is not possible to compare sheltered coasts in Tasmania with similar shores in New South Wales, as very little work has been carried out describing the ecology of sheltered conditions in the latter State.

In conclusion, the Supralittoral Fringe of New South Wales closely resembles that of Tasmania in its general bareness. The presence of *Nodilittorina* of the coasts of New South Wales is a feature not found in Tasmania. The barnacle population of the Midlittoral in New South Wales is more dense than in Tasmania. Not only are there more species found on the Mainland but the density of population is very much greater than in Tasmania, where the cirripedes are frequently confined to semi-cryptic places. On sheltered coasts of New South Wales the presence of an oyster belt is a feature which is absent from Tasmania. The Infralittoral Fringe of exposed coasts in New South Wales is dominated by *Pyura-Ecklonia*, whereas in Tasmania the species are entirely algal, namely the Corallines and *Sarcophycus*. There is no Patelloid belt in New South Wales.

(c) Victoria

There is no literature describing Victorian intertidal conditions and it is not possible to make a detailed comparison of the Tasmanian and Victorian coasts. Pope (1951*b*) states that the Victorian coast shows conditions which are intermediate between those of New South Wales and Tasmania.

(d) South Australia

The only comprehensive information on the intertidal zones of South Australia is contained in the publications of Womersley and Edmonds. Johnston and Mawson (1946) give a very brief outline of the fauna of the Adelaide beaches. Womersley and Edmonds have both worked extensively on Kangaroo Island.

The salient feature of Kangaroo Island is that the algae are the dominant forms over most of the shore. Edmonds (1948, p. 175) states that the algae are the dominant species of the rock platforms but there are certain animal belts to be recognised. These belts are *Melaraphe, Chthamalus, Galeolaria,* Patelloid and mussel bands. *Catophragmus* is present in places with strong wave action, also a few *Balanus nigrescens.* The Infralittoral Fringe is populated by algae, of which *Cystophora, Sargassum* and *Ecklonia* are the dominant genera. *Pyura praeputialis* is not found in South Australia but *Boltenia australis* is present in the Infralittoral Fringe.

The fauna of Kangaroo Island intertidal region closely resembles that of a semi-exposed coast in Tasmania but the animal zonation may be obscured by an algal zoning. The presence of mussel beds in Kangaroo Island (*Brachyodontes rostratus*) as well as in Tasmania is of considerable importance. Similarly the presence of a Patelloid band in both States is of importance in assessing certain geographical affinities. *Sarcophycus* is confined to Tasmania as is the coral-like *Lithophyllum.* The Corallines are well developed in both areas.

Conclusion

Figure 1 shows the relation between the intertidal zones on an exposed coast in the various States of Australia with the exception of Western Australia and Victoria. This zonation is correlated with that of Stephenson & Stephenson (1949). It can be seen from the text and this table that with the exception of the barnacle and littorinid belts, the zones seen on the coasts of Tasmania and tropical Queensland are very different. These two belts are a universal feature of intertidal life. The coasts of the Mainland show greater affinity with Tasmania the nearer they are to that State, but probably the greatest resemblance is to be found in South Australia where the animal belts are the same as in Tasmania. It is possible that recent work in Victoria will show that the coasts of Victoria are ecologically similar to Tasmanian shores. The presence of mussel beds and *Sarcophycus* in Victoria shows that there is a considerable resemblance between the intertidal life of these two States.

Problems relating to the distribution of some species and some geographical considerations

(a) Barnacles

As noted in several parts of this paper the barnacle fauna of Tasmania is poor both in numbers and species. The only common species are *Chthamalus antennatus, Chamaesipho columna, Elminius modestus, E. simplex* and *Catophragmus polymerus. Tetraclita purpurascens* is found less frequently.

The barnacle fauna is found at its maximum development on semi-exposed coasts, where *Chamaesipho* and *Chthamalus* are plentiful. Fully exposed coasts do not support a prolific barnacle fauna but *Catophragmus* may be very numerous in a belt in the lower part of the Midlittoral. On sheltered coasts there as usually very few barnacles and these are often confined to semi-cryptic places. Some sheltered coasts are virtually devoid of cirripede belt, e.g., Oyster Cove.

A shore on which there is extensive but not heavy surf supports a good barnacle fauna. To experience such a surf a coast should be exposed to moderate action and the shore profile be a gentle slope which allows the waves to rush for some distance up the rocks. The dense barnacle growths at Betsy Island and Frying Pan Island have been described above.

Sun exposure does not seem to be one of the factors which limit the barnacle population. At Betsy Island the dense population of *Chthamalus* is on the sun-exposed side of the island and the barnacles experience the full effect of the sun, though this may be considerably modified by the amount of splash and spray received by the animals. At Sleepy Bay the barnacles live in small clusters which are often found on sun-exposed rocks, though at Blackman's Bay the barnacle population is most dense in places where there is some shelter from the sun. The principal evidence against sun exposure as a controlling factor in Tasmania lies in the fact that the same species of barnacles are found on the shores of New South Wales or Queensland where the sun exposure is greater than any encountered in Tasmania. In general in Tasmania barnacles do not seek shade from the sun except in half sheltered situations such as Triabunna, Oyster Cove and parts of Blackman's Bay.

Fischer (1940) suggests that the Australian littoral fauna is primarily tropical in its affinities and has been slowly acclimatized to cooler conditions by a gradual recession of the warmer water over a period of geological time. Further evidence for this is seen in the " inlier " of molluscs with New South Wales affinities in the Great Australian Bight as quoted by Hedley (1915). The summer on-shore flow of the warm Notonectian Current would help to maintain a warm water element in temperate seas by raising the sea temperature to a breeding temperature and also by bringing down larvae and/or adults from a warmer climate breeding stock. The plankton of Tasmania is warm water in nature and receives little cold water reinforcement (Fairbridge, 1949) which further supports Fischer's theory.

Further support for the tropical recession theory of Fischer is found in a statement by Kenny (1950) who says that there are no barnacles on Macquarie Island. This island is 600 miles south of Tasmania and situated well away from the influence of the warm tropical currents. The Southern Drift passes the island and effectively cuts it off from any Australian hydrological or biological influences. At some time in the past Macquarie Island may have had a barnacle fauna composed of Australian warm water elements. If such a fauna once existed there it failed to adapt itself to the cold conditions of the Southern Ocean and has become extinct. No reinforcements of Australian barnacle larvae can reach the island and a " barnacle vacuum " has been created. The vacuum cannot be filled by other species on account of the distance from

other breeding stocks, possibly Heard Island, Kerguelen Island or Cape Horn. Because of this vacuum it seems possible that Macquarie Island once supported an Australian fauna. It might be pointed out that Macquarie Island is neither ice bound nor frozen over in winter so that ice action cannot affect the intertidal fauna.

It is noticeable that barnacles on the northern coast of Tasmania, e.g., at Burnie and Boat Harbour, are not only much larger but also more numerous than in the south and east of the island. The barnacles on the western coast are similar in size to those found in the south.

It has been inferred that the effect of cold winter nights combined with tidal effects is more harmful to intertidal animals than exposure to the summer sun. The persistent failure of barnacles to colonize rocks after successful spatfalls points to an unsuitable environment and has been attributed to cold winter nights.

It is suggested that Tasmania is at about the limit of cold toleration of the barnacles which are the relics of a warm water fauna. Warm waters wash the shores of Tasmania and it is the presence of this warm water than enables the barnacles to survive in Tasmania. Australian barnacles do not occur on Macquarie Island because the water is too cold. If the habitat were suitable it is probable that colonization would have been effected by larvae liberated from ships visiting the island, once an important sealing station. The barnacle vacuum on Macquarie Island may have been caused by the recession of warm water or by the recent geological appearance of the island, either of these factors combined with the distance of the island from a permanent barnacle breeding stock.

(b) Pyura

Pyura praeputialis is very plentiful on the exposed coasts of New South Wales, where it forms dense aggregations of individuals at the lower levels of the shore. Hedley (1915) recorded the species as being very common wave exposed places but Dakin, Bennett and Pope (1948) have modified Hedley's statement and found the species in oceanic waters with some wave action. Other workers have found related species of *Pyura* on wave exposed places in South Africa and New Zealand. Similarly, *Pyura chilensis* is common on the coasts of Chile.

There is little disagreement between any of the results from the above countries, but the distribution of *Pyura praeputialis* in Tasmania does not fully conform to any of the above conclusions. On most of the wave exposed coasts of Tasmania the species is rare. At the Freycinet Peninsula for example, there are about 2 ascidians on every 40 yards of shore. At Point Seymour the species is slightly more abundant. At both these places the density of population does not vary with the wave exposure. At Pirates Bay in South-Eastern Tasmania the species forms beds along the shore at the lowest tidal levels, but these beds are not in a position where they are exposed to heavy wave action. The wave action which they experience might be considerable but it would not be as much as they would experience on the ocean coast. It is probable that the distribution here agrees with that noted by Dakin, Bennett and Pope.

The species is rarely found forming beds in Tasmania on exposed coasts. Mr. Cribb tells me that it is found on the eastern shores of Port Arthur and I have found it forming beds on the exposed shore at Remarkable

Cave. These are the only two places where I know of the species being found on exposed coasts in large numbers.

In Tasmania the species is most common in places where there is sheltered water. We find it forming masses on the sheltered side of the Freycinet Peninsula, in Dunalley Canal, at Dodges Ferry, Carlton, on piles at Pittwater and on jetties throughout D'Entrecasteaux Channel. At the Freycinet Peninsula and possibly D'Entrecasteaux Channel the water is oceanic in character. Some parts of the Channel experience estuarine conditions and the ascidians are found in large numbers in such positions. At Pittwater there is considerable dilution of the water after rain and Dodges Ferry and Carlton experience a lesser degree of dilution. At Pipe Clay Lagoon the species lives in hypersaline water in the summer as the salinity has been recorded as high as 37 grs./mille.

Apart from one or two exceptions the largest beds of the ascidians are found in the more sheltered situations, most of them being without oceanic water. The ascidians are rare on exposed coasts.

In some exposed places the ascidian and *Sarcophycus* are in competition for space. The absence of this alga from the New South Wales coast may leave more space for colonization by the ascidian, but this does not explain the obvious preference of the species for sheltered places. Mr. R. Endean has suggested that the ascidian may have two ecological varieties, one found on a sheltered coast and the other living on exposed places. This possibility is being investigated at present.

Is the species reaching the end of its geographical range and seeking a more sheltered habitat in a similar fashion to *Ecklonia*?

(c) Mytilus

A salient feature of semi-exposed coasts in Tasmania is the presence of large beds of the mussel *Mytilus planulatus*. The beds are usually found in the lowest part of the Midlittoral. In South Africa *Mytilus perna* is a feature of exposed coasts but in Sydney, Hedley states that mussels do not form an important part of the intertidal region.

In Tasmania, if the mussels are found in beds, the species is very rarely found in the upper levels of the shore. If beds are not present, then mussels may or may not be found at high shore levels.

In wave sheltered places the mussels are found at various levels on the shore and do not usually form beds. In Barnes Bay the species is found at various levels on the shore as high as the upper limit of the tides. The mussels in this place are sheltered from the sun by high trees, but in other places in nearby inlets the mussels are found nearly as far up the shore but they are not sheltered from the sun.

If the mussels are capable of living at such high tidal levels, why are the mussel beds characterised by a sharp upper limit? Also, why are there no clusters of mussels on the shore at a higher level than the beds? On semi-exposed coasts the presence of a certain amount of spray would tend to assist the mussels to live at higher levels but the species is found furthest up the shore in sheltered places.

Similarly, why is there such a sharp limit to the lower level of the mussel beds? It has been suggested by Newcombe (1935) that starfish and carnivorous gastropods are responsible for the sharp lower limit of the beds of an American species of mussel. In Tasmania I doubt if

there are a sufficient number of active intertidal predators to cause such a limit. The answer more probably lies in a modification of the conclusion of Kitching that slow growing perennials eventually dominate over large species.

Geographical Conclusions

It is possible briefly to compare the intertidal region of Tasmania with that of New Zealand, South Africa and Chile. In making any such comparisons it is advisable for the worker to have seen the features of the countries being compared as there is a considerable difference in the interpretation of wave exposure by authors. The value of talks and personal visits has been shown in the conversation with Miss Pope noted previously. These conclusions must be treated with a certain amount of reservation but in the main, I think that certain features can be compared with accuracy.

(a) New Zealand

The most important literature describing the coasts of New Zealand is the works of Oliver (1923), Cranwell and Moore (1938), Beveridge and Chapman (1950), Ambler and Chapman (1950), Dellow (1950) and Chapman (1950). Several of these papers are confined to the algal communities but Oliver, Cranwell and Moore and Dellow give a picture of the animal zonation as well as that of the plants.

In many respects the shores of New Zealand closely resemble those of Tasmania. The Supralittoral Fringe in New Zealand is populated by lichens and Cyanophyceae with *Melaraphe* in the lower limits of the region. This is very similar to the conditions noted in Tasmania but is not the only resemblance as there is a *Chthamalus* belt which has *Actinia tenebrosa,* a Patelloid and *Porphyra* living in it (Cranwell & Moore). In other places *Chamaesipho columna* replaces *Chthamalus* and the algae are of greater importance (Dellow). *Hormosira* and the Corallines are both present in New Zealand. *Mytilus planulatus* and *M. canaliculatus* form beds in New Zealand with *Ulva, Pinnotheres, Plaxiphora, Turbo, Elminius plicatus* and *E. modestus, Cellana,* and *Sypharochiton pellis-serpentis,* e.g., at Taylor's Mistake (Oliver, 1923). These mussel beds in their generic and even their species composition closely resemble those of Tasmania.

It is interesting to note that there is also a *Modiolus pulex* association which is very similar to the Tasmanian *Brachyodontes rostratus* beds. These New Zealand mussels are found near high water mark, which is much higher than is the case with the Tasmanian species.

Under certain conditions of shelter from wave action there are oyster beds in New Zealand composed of *Ostrea cucullata.* This is the same species as is found at Sydney.

The *Galeolaria* beds of Tasmania are replaced by the *Hermella-Vermilia* associations as described by Oliver (1923) and Dellow (1950). Plate 48, Figure 2 of Oliver closely resembles the conditions found on Pipe Clay Lagoon.

Corallina, Hormosira, Xiphophora and the Patelloids are all found in New Zealand and form prominent bands on the shore. The genus *Sarcophycus* is absent from New Zealand but is replaced by *Durvillea* which looks very similar in appearance. *Durvillea* is found on the wave exposed coasts and occupies a similar niche to *Sarcophycus.*

From the accompanying table (Table V.) it can be seen that there are very close affinities between not only the appearance of the belts comprising the intertidal belts of Tasmania and New Zealand but in many cases the species are identical. There are some elements of the Sydney fauna and flora found in New Zealand, namely the Oyster belt and *Ecklonia*. *Ecklonia* appears to be better developed in New Zealand than in Tasmania as it is found in restricted areas in Tasmania. The oyster belt is absent from all coasts of Tasmania.

Table V

Zone forming species found on various types of coast in Tasmania and New Zealand.

(a) Tasmania	(b) New Zealand
Lichens	Lichens
Melaraphe	*Melaraphe*
Chamaesipho columna	*Chamaesipho columna*
Chthamalus antennatus	*Chthamalus antennatus*
Elminius modestus & E. simplex	*Elminius modestus & E. simplex*
Hormosira banksii	*Hormosira banksii*
Patelloids	Patelloids
Mytilus planulatus	*M. planulatus & M. canaliculata*
Brachyodontes rostratus	*Modiolus pulex*
Galeolaria	*Hermella*
—	*Ostrea*
Pyura	*Pyura*
Corallines	Corallines
Sarcophycus	*Durvillea*
Xiphophora	*Xiphophora*
Lessonia	*Lessonia* (in Sublittoral, Moore).
Ecklonia	*Carpophyllum-Lessonia* (Oliver)
	Carpophyllum-Ecklonia (Dellow)
Cystophora	?
Zostera	*Zostera*
Macrocystis	*Macrocystis*
Amphidesma (surf beaches)	*Amphidesma* (surf beaches)

The presence of the southern alga Durvillea in New Zealand is a feature which is not found in Tasmania, though *Sarcophycus* looks very much the same in both external appearance and habitat. *Durvillea* is only recorded from Tasmania as driftweed.

(b) South Africa

The most important literature dealing with the South African intertidal region is that published by a team of workers under the direction of Prof. T. A. Stephenson. These publications are Stephenson, Stephenson & duToit (1937); Bright (1938*a-b*); Stephenson, Stephenson & Bright (1938); Eyre & Stephenson (1938); Eyre, Broekhuysen & Crichton (1938); Eyre (1939) and Stephenson, Stephenson & Day (1940). This important survey is summarized in three papers by Stephenson (1939, 1944 and 1948). There are also several other papers on special topics connected with this survey but they do not directly concern this general comparison.

The *Littorina* and barnacle zones in South Africa have a very wide range, extending from Natal to the West Coast. This is similar to Australian conditions.

The temperate Indian Ocean coast and the East London area resemble New South Wales more than Tasmania because of the prevalence of *Pyura* in the Infralittoral Fringe. The occurrence of a widespread Patelloid zone in South Africa is more a Tasmanian feature than one with Mainland affinities. In view of the mixing of Patelloids and *Pyura* it is possible that this part of South Africa resembles the southern coasts of Victoria, where a mixing of Tasmanian and New South Wales features is found. It is also possible that False Bay (Eyre, 1939) has an equivalent area on the coast of New South Wales.

The Durban area resembles Queensland and does not come into the scope of this comparison.

The West Coast of South Africa (Bright, 1938*a-b*) & Stephenson, Stephenson and Day (1940), shows the greatest resemblance to Tasmanian conditions. *Macrocystis* is found off-shore and the algae of the Infralittoral Fringe are *Laminaria* and *Ecklonia*. The former occupies almost the same niche is *Sarcophycus*, but differs in the nature of the holdfast which is not sucker as in *Sarcophycus*. The presence of large amounts of *Ecklonia* is not a feature which can be shared with Tasmania because of the restricted distribution of that alga in Tasmania. In South West Africa there is a very well developed *Cochlear-Argenvillei* belt. This is the equivalent of the Patelloid belt in Tasmania.

Pyura is found in some places on the S.W. African coast. This might be a similar feature to that seen in Tasmania where the species is not widespread but is restricted to patches on exposed coasts. As noted above, it is very common in sheltered places in Tasmania.

Bright (1938*b*) reports that where there is heavy surf the mussels *Mytilus meridionalis* are encountered. This is a different habitat from that occupied by mussel beds in Tasmania but it is important to note that mussels form beds in S.W. Africa.

Oysters do not form a band in either S.W. Africa or Tasmania. The barnacles and littorinid belts are found in both countries though it appears from the literature that the barnacle belt in Africa is more densely populated than its Tasmanian equivalent.

(c) Chile

Macrocystis pyrifera is common off-shore on the west coast of Chile. *Durvillea* is widespread from Coquimbo around Cape Horn to the Atlantic Ocean (Etcheverry, personal communication). The genus *Lessonia* is also very common in Chile but is more sublittoral in nature. The zonation on an exposed Chilean coast is:—

Littorina peruviana or *L. araucana*
Barnacles
Corallines
Pyura chilensis
Durvillea antarctica

The resemblance between this type of zonation and that encountered in Tasmania is very close.

Conclusion

It can be seen from the above brief comparison that the intertidal zones of Tasmania, New Zealand, Chile and South-West Africa closely resemble each other in appearance. In several instances the species are the same, e.g., *Macrocystis pyrifera* is common to all countries, *Durvillea antarctica* is found in two countries. In other cases the genera are the same, e.g., *Mytilus*. There are other common features such as the presence of serpulid masses in sheltered waters and the distribution of *Ecklonia*. The presence of an oyster belt in New Zealand is the only character of that country not found in Tasmania.

There is a cold water flora and fauna of the character listed above extending round the southern end of the great continental masses of the Southern Hemisphere, and including the subantartic islands and New Zealand. In S. America, the Chilean coast falls into this belt, the South West African coast, New Zealand and Tasmania also fall into this belt. Ecologically the Tasmanian coasts have a greater affinity with New Zealand or Chile than with the shores of South Australia, though Tasmania and S. Australia are both in the Flindersian Region. This belt can conveniently be called the southern region of giant brown weeds and is characterised by the presence of large Phaeophytes, Patelloids, mussel beds and Corallines. The belt follows the distribution of *Durvillea* as shows by Fritsch (1945, Map 2).

The flora and fauna of the coasts of Tasmania, New Zealand, Chile and S.W. Africa are all cold water in nature. The low temperature of the waters of Tasmania and New Zealand are maintained by the colder seas while S.W. African seas are kept cold by an upwelling of cold water much in the same fashion as the Chilean coast is also kept cold. In South America the cold Humboldt Current enables the large brown weeds to survive as far north as California (Chapman, 1950). The presence of *Ecklonia* in New Zealand and S.W. Africa indicates that those waters may be slightly warmer than the seas round Chile and Tasmania. The following table illustrates the similarity in the zones to be seen on exposed coasts in the giant brown weed belt.

Table VI

Correlation of intertidal zones on nearly exposed coasts in Chile, Tasmania, S.W. Africa and New Zealand. The Chilean zonation is based on communications from Dr. Bahamande, Prof. Riveros-Zuñega, Dr. Etcheverry and Prof. H. Brattstrom.

Tasmania	*New Zealand*	*S.W. Africa*	*Chile*
Littorinids	Littorinids	Littorinids	Littorinids
Chamaesipho & Chthamalus	Chamaesipho & Chthamalus	Balanus	Chamaesipho & Balanus
Galeolaria	Hermilla	Pomatoleios	Serpulids
Corallines	Corallines	Corallines	Corallines
Sarcophycus	Durvillea	Laminaria	Durvillea
Macrocystis	Macrocystis	Macrocystis	Macrocystis

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Revised Interpretation of the Geology of the Smithton District of Tasmania

By

S. Warren Carey and Beryl Scott

WITH 2 PLATES AND 1 TEXT FIGURE

Abstract:

The geology of the Smithton district is described in Bulletin No. 41 of the Geological Survey of Tasmania. The abundance of vesicles and amygdules mentioned in the description of the doleritic rocks which form a prominent feature of the area, seemed inconsistent with their interpretation as intrusive dykes and prompted us to check their occurrence in the field. We report that these rocks do in fact contain abundant vesicles and amygdules, and that in places they exhibit pillow structure and are associated with volcanic breccias and volcanic bombs. We have examined the exposures on which an intrusive character was claimed and are satisfied that they are due to extrusive and volcanic phenomena similar to those we have studied in the Cambrian or Late Proterozoic volcanic suite on King Island, 80 miles to the north-west. Native copper which is described as a common constituent, we find to be not native copper but pyrrhotite. " Fine-grained silicified conglomerate interbedded with dense black cherts exposed in the Irishtown gravel pits " (loc. cit. p. 31), we find to be silicified oolite. The two formations of dolomite described in the bulletin we consider to be a single formation repeated by strike faulting.

We agree with the previous authors in their correlation of their " Slate Stage " with the Dundas Group. We also correlate this group with similar rocks outcropping on the east coast of King Island and suggest that the tillite found in close association with these rocks in several parts of the State is part of the Dundas Group and is of Cambrian age. We suggest that a silicified breccia described by the previous authors is possibly the representative of the tillite in the Smithton district.

Introduction

The geology of the Smithton district of North-west Tasmania has been described in detail by Nye, Finucane, and Blake, in Bulletin No. 41 of the Geological Survey of Tasmania. A prominent feature of the geology of the district as described by the authors is a broad but rather complex dolerite dyke having a general meridional trend which the authors suggest to be of Devonian age and intrusive into the Dundas Slates and Breccias of Cambro-Ordovician (now known to be Middle Cambrian) age. Their descriptions of these rocks made frequent reference to the presence of amygdules.

For example:—

> p. 66.—" The white amygdules consist mainly of aggregates of quartz and calcite which may contain augite or chlorite. The green amygdules consist of a central nucleus of quartz, surrounded by fibres of the same material, with a thin outer layer of chlorite; the fibrous quartz between the nucleus and the outer chlorite layer radiates in fan-shaped fashion from a number of points on the inside of the chlorite layer. In a small outcrop of the dolerite on the northern spur of Tier Hill the white amygdaloidal inclusions are so numerous that the rock has quite a coarse appearance ".

p. 68.—" There are two main types . . . . . both are amygdaloidal ".
p. 69.—" The amygdules consist of quartz and chlorite; in some cases the chlorite occupies the centre of the amygdule, and is surrounded by quartz; in others the amygdule is of quartz surrounded by a thin film of chlorite ".
p. 69.—" The amygdules are small vesicular cavities lined with quartz ".

These descriptions of abundant amygdules seemed to us inconsistent with the view expressed by the authors that these rocks were intrusive. In addition one of us (B.S.) has been studying the Cambrian or Late Proterozoic basic lavas of Tasmania generally, and has found them to be widely distributed in the area between Queenstown and King Island, and this suggested that the amygdaloidal basic rocks at Smithton associated with the Cambrian Dundas Group might in fact be another occurrence of these old lavas.

Extrusive Character of So-Called Dolerite

We examined the " dolerite dyke " in the following localities: Tier Hill, Coward's Road, the quarry ¾-mile south of Groom's Road on the Smithton-Trowutta Road, along the eastern shore of Duck Bay, and for a distance of about ¾-mile eastwards from Park Point along the shore. In each of these localities there was strong evidence to support an extrusive rather than an intrusive origin.

Throughout this paper the term " dolerite dyke ", as used by Nye, Finucane and Blake, will be replaced by " basic volcanics ".

The basic volcanic rocks occupy a similar stratigraphical position in the Dundas Group to those which crop out along the south-east coast of King Island and at Zeehan. For the most part they overlie well bedded chocolate coloured shales, but as on King Island, volcanic activity commenced before deposition of the shales was completed.

About 30 to 35 chains east of Park Point occurs a bed of volcanic breccia, fragments of which range from about ¼-inch to 1-inch in diameter with a few up to 3 inches. The fragments are generally angular and are composed of very fine grained greenish-grey volcanic rock, cemented together by dark chocolate-coloured shaley material. (see Plate I, Fig. I). It seems that showers of volcanic material fell on to the unconsolidated mud which probably oozed up between the fragments of lava. The description on pp. 70-71 (*loc. cit.*) of a thin section of the altered basic augite porphyrite which was assumed to occur in dykes and tongues on the eastern margin of the dolerite dyke could be applied to thin sections of the fragments of rock in the breccia, examined by us. It seems to be no more than a quickly cooled phase of the main rock type. The similarity between the main dolerite rock type and the basic augite porphyrite is also borne out by the chemical analyses given in the bulletin.

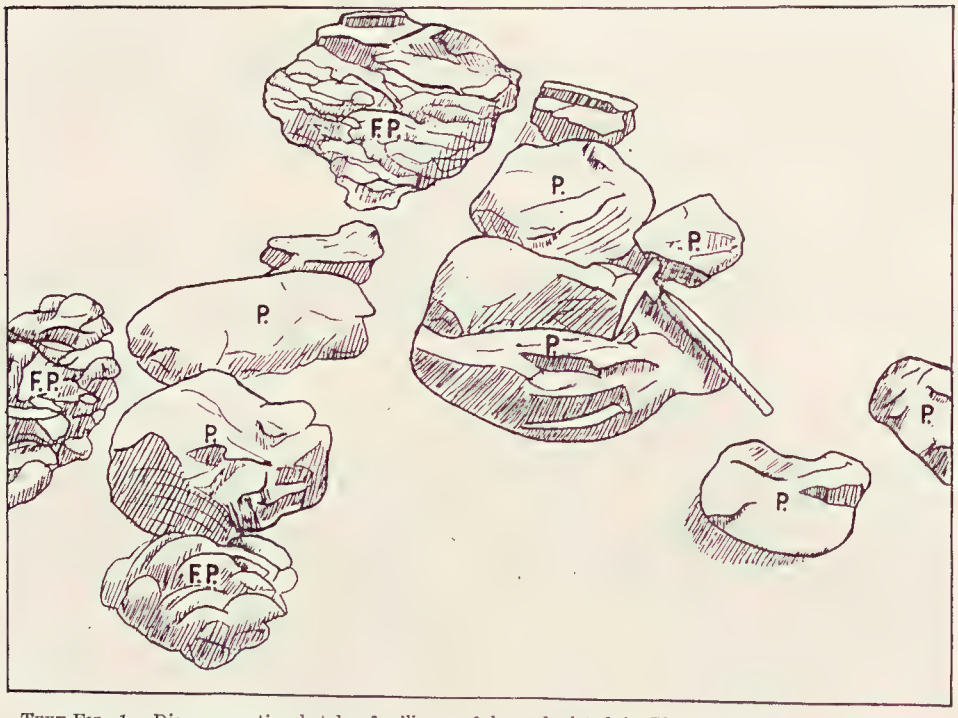
Closely associated with the breccia are volcanic bombs which fell on unconsolidated mud. These bombs are not nearly so numerous as the fragments of the breccia. They vary from about 2 inches to 12 inches in diameter, the most common size being about 4 inches. The exceptional number of vesicles which in places gives the rock an appearance of pumice, indicates quick cooling, and on examination of a thin section the state of incipient crystallization of the rock also confirms the condition of cooling. Needles of plagioclase appear to be embedded in a groundmass of devitrifying glass. Numerous microscopical vesicles

filled with quartz and chlorite are also present. An illustration of a bomb appears on Plate I, Fig. 2. Some of the bombs have re-entrant and irregular shapes on cross sections exposed by weathering, but it appears that the bomb when it fell into the mud was still hot enough to be plastic under its own weight, with the result that bulging deformation or viscous protrusion occurred leading to concave and (in section) re-entrant profiles.

The association of the breccias and volcanic bombs with the slates was given an entirely different interpretation by Nye, Finucane and Blake on pp. 72-73; "the slate appeared to be undergoing digestion by the dolerite, the process resembling magmatic stoping on a minute scale".

Overlying the fragmental rocks is a dense massive fine grained, greyish-green lava in the same relative stratigraphical position as the massive lavas of King Island. Petrographically the rock resembles those on King Island and their correlates elsewhere in Tasmania. Microscopic descriptions appear in the bulletin on pp. 65-66. One slide of a porphyritic rock appears to contain phenocrysts of olivine which have been completely pseudomorphed by chalcedony and bright green nickel bearing chlorite. None of the original mineral remains but the crystal outlines and the fact that the pyroxene in the slide is fresh indicate olivine. On p. 69 the presence of biotite is mentioned. "Chlorite and biotite occur as interstitial grains; the latter is not common". In all the sections of rocks examined not a trace of biotite has been found but hydrogrossular, a brown coloured mineral in ordinary light, has been noted and when present is usually associated with chlorite as interstitial grains and in vesicles or replacing tiny crystals of olivine. It is possible that this mineral, a member of the hydrogarnet series, has been mistaken for biotite. The occurrence of hydrogarnet in the King Island lavas has been described recently by one of us (Scott, 1951). Whenever possible the plagioclase was studied carefully. It was on all occasions found to be albite and to show the characteristic clear appearance under high power. In some sections it showed alteration to chlorite and very rarely to epidote. In parts this massive lava is quite amygdaloidal or vesicular, this phenomenon being most noticeable in the rocks outcropping on Tier Hill and in the quarry along the Smithton-Trowutta Road. The vesicles may be oval or irregularly shaped and vary from microscopical dimensions to about $\frac{3}{8}$-inch in diameter. The infillings are generally quartz, albite, calcite, chlorite and epidote. We can account for the augite recorded from the vesicles by the previous authors (p. 66) only by assuming that some of the epidote was indentified as augite.

The next rock type in the suite appears to be the pillow lava which is found along the eastern shore of Duck Bay. The pillows (see Plate I, Fig. 3, & Text-Fig. 1) range from 1 foot to 6 feet in diameter, and were immediately recognized because of their similarity to those on King Island, notwithstanding the fact that the Smithton pillows are more broken up by mechanical weathering. Between the pillows is to be found banded tuff, the misinterpretation of which may have contributed to the theory of an intrusive origin. Microscopically the rock type closely agrees with the description of the mugearites given on pp. 68-70 and it seems possible that the so-called tongues and dykes of mugearites have



TEXT-FIG. 1.—Diagrammatic sketch of pillows of lava depicted in Plate II, Fig. 3. P. = pillow. F.P. = pillow fractured by weathering.

been confused with the pillow lavas. The pillow lava consists of laths of plagioclase approximately 0·5 mm long with interstitial chlorite, magnetic and possibly ilmenite, and tiny needles of apatite. The plagioclase shows quite good albite twinning, has an extinction angle of 17° and a refractive index less than Canada balsam indicating albite with the composition $Ab_{95}An_5$. The chlorite is greenish-brown in colour and has probably been derived from the pyroxene, no fresh grains of which still remain. From the mineralogical and chemical composition this rock type would better fit the name of spilite, although the CaO and MgO contents are rather lower and the Al_2O_3 content rather higher than usual for spilites.

Several chemical analyses have been given in the bulletin and on the basis of these and the microscopical descriptions the rocks were divided into fine grained and porphyritic varieties of dolerite, mugearites, and augite porphyrites. However, with the experience of one of us (B.S.) in studying similar ancient volcanics elsewhere in Tasmania it seems that such a classification is unnecessary. Generally speaking there is not a great deal of variation in the rocks either mineralogically or chemically. The slight variation chemically may be accounted for by the slight difference mineralogically and by various stages of hydrothermal alteration, the vagrant constituents usually being Al_2O_3, CaO, MgO, and Na_2O.

To summarise, the evidence on which we base our belief that the igneous rocks are extrusive rather than intrusive is:

(i) Great abundance of vesicles and amygdules.
(ii) Presence of pillows, volcanic bombs, and breccia.

(iii) General homogeneous fine grain-size inconsistent with the great volume and thickness of basic rock regarded as an intrusion.

(iv) The similarity in broad characters and in details to known basic lavas occurring in the same stratigraphic group, with a distribution which straddles the Smithton occurrences.

That small dykes associated with the volcanic rocks exist is not denied. The rock material in them is essentially the same as the volcanic type. Such cognate dykes are a common feature of the King Island volcanic suite.

Re-Determination of So-Called Native Copper

Scattered rather abundantly through the basic volcanic rocks are specks and flakes of a copper coloured mineral referred to in the bulletin as native copper. A similar looking mineral has been found in much less abundance in the King Island basic volcanic rocks associated with a dark green chlorite (the nickel-bearing variety garnierite). This was thought to be nicolite which megascopically resembles native copper (Scott, 1951). The so-called native copper of the Smithton rocks is also associated with nickel bearing chlorite. However, chemical and magnetic tests by one of our students (R. J. Ford) have now established that the mineral is pyrrhotite, probably containing some nickel. No chemical reaction for copper even in small quantity could be obtained. It is probable that the King Island mineral is actually nickel bearing pyrrhotite also. It is of interest to record that we have observed the same nickel bearing chlorite associated with the basic lavas at Heathcote, Victoria, which are recognised as correlates of the Dundas Group, to which the Smithton lavas are also referred.

Possible Occurrence of Tillite

The previous authors have described a silicified breccia which outcrops as a small rocky headland about 10 chains west of the mouth of Deep Creek. Stratigraphically it is at or near the base of the Dundas Group. In its general appearance it closely resembles some phases of the tillite at King Island and at Zeehan. However pebbles and matrix are completely silicified and there is no possibility of extracting striated pebbles to confirm the glacial origin. Its position with respect to the basic lavas is analogous to the position of the tillite at King Island and at Zeehan. Complete metasomatic replacement is a common phenomenon in the tillite elsewhere. At King Island some outcrops are dolomitised, both the pebbles and the matrix being wholly replaced by dolomite. Elsewhere the replacement is by haematite. We suggest that this Smithton breccia may be tentatively correlated with the tillite though it should be emphasized that a glacial origin cannot be established on the evidence available in the Smithton district alone.

Re-Determination of Silicified Conglomerate as Silicified Oolite

On page 31 of the bulletin the previous authors described a silicified conglomerate in their " Chert Sub-stage " in the following terms: " In the Irishtown road gravel pits, about a mile south of Smoker's Bank road, a fine-grained silicified conglomerate is interbedded with dense black

cherts and grey and purplish-grey slates. The rock is composed of rounded, with some angular, quartzose pebbles, set in a siliceous matrix. The pebbles are black or white in colour, and remarkably uniform in size; their diameter is one-eighth to three-sixteenths of an inch. The rock sometimes has the appearance of a silicified grit, but, as the bulk of the pebbles are rounded, it corresponds more to a fine grained conglomerate. Grey and purplish-grey slates are interbedded with the above members".

We had no difficulty in identifying the locality and found the rocks answering closely to the description of the so-called silicified conglomerate. However we find the rocks to be not a silicified conglomerate but a silicified oolite (See Plate I, Fig. 4). Microscopically the silicified oolite indicates complete replacement of the original carbonate by quartz. Definition of the individual oolites is less distinct than in hand specimen where colour plays an important role. Both the oolites and the material between them consist of finely granular quartz. The quartz grains in the oolites are a little larger and in some cases towards the centre may grade to 0·5 mm. Macroscopically, the rock is sometimes deeply pitted, presumably owing to removal in solution of unsilicified carbonates.

Relation of "Chert Sub-Stage" to Dolomite "Sub-Stage"

The previous authors suggested (p. 30) that their Dolomite Sub-stage is intimately associated with the Chert Sub-stage, and that it underlies or forms the base of the Chert Sub-stage. We go somewhat further and suggest that the "Chert Sub-stage" of the previous authors has no separate existence as an independent formation but is merely the result of widespread silicification of part of the Smithton dolomite and also in places of the lower part of the overlying Dundas Group. Most of the cherts have the texture and characteristic jointing of the dolomite. Shallow solution depressions occur within areas mapped as Chert Sub-stage indicating the removal by solution of residual unsilicified dolomite (e.g., near where Fahey's Lane crosses the Smithton-Irishtown Railway). Complementarily, the previous authors write (p. 28) concerning their "Dolomite Sub-stage" that in many cases the rock is partly or wholly silicified, the complete silicification producing a chert. At Nabageena irregular areas are replaced by chert while the dolomite also appears to be interbedded with cherts, which may also represent complete replacements of dolomite beds. The silicified oolite described above, which is part of the Chert Sub-stage was derived presumably from oolitic dolomite. If the Chert Sub-stage (excluding fringes regarded as belonging to the Dundas Group) and the Dolomite Sub-stage are combined as a single formation, the former being regarded as a silicified form of the latter, the combined outcrop makes a reasonable structural picture. (See Plate I.)

Revised Stratigraphic Sequence in the Smithton District

The stratigraphic sequence as given by the previous authors is as follows:—

		Approx. thickness in ft.
(vi)	Upper Slate and Breccia Stage	
(v)	Dolomite Stage	3000-9000
(iv)	Slate Breccia and Limestone Stage	4000
(iii)b	Chert Sub-Stage	2000

		Approx. thickness in ft.
(iii)a	Dolomite Sub-Stage	1000
(ii)	Grey-Green Quartzite Stage	3000
(i)	White Quartzite Stage	1500

Of these formations we suggest that the White Quartzite Stage is a more silicified variant of the Grey-Green Quartzite Stage. As pointed out above we consider that the Chert Sub-stage (iii)b is a silicified variant of (iii)a, the Dolomite Sub-stage. We also consider that there is a large strike fault separating Stages (iv) and (v) causing a repetition of the sequence so that the Dolomite Stage (v) is a repetition of the lower Dolomite (iii)a and (iii)b, and the Upper Slate and Breccia Stage (vi) is a repetition of the Lower Slate Breccia Stage (iv).

The revised stratigraphic sequence of the Smithton district thus becomes;

			Stages of Nye, *et al.*	Approx. thickness
Cambrian	DUNDAS GROUP	Slates, Breccias basic lavas and tuffs	(iv), (vi).	5000
Lower Cambrian or *Late Pre-Cambrian*	CARBINE GROUP	Smithton Dolomite	(iii)a, (iii)b, (v).	3000
		Bryant Hill Quartzite	(i), (ii).	3000

The previous authors have described two occurrences probably of the same bed of blue limestone which occurs within a few hundred feet of the highest exposure of the Dundas Group in the area. This limestone contains structures determined by Chapman as crinoid osicles, and traces of other organic remains so far unidentifiable. The stratigraphic position of this limestone is uncertain. No limestones have been recorded from the Dundas Group in Tasmania although the correlates of the Dundas Group in South Australia do contain limestone. However the facies of the Dundas Group in the Smithton district as elsewhere in Tasmania is typically eugeosynclinal whereas the facies of the correlates in South Australia are miogeosynclinal. On palaeogeographic grounds therefore, the limestone is somewhat alien in the Dundas Group. However, the overlying Junee Group in Western Tasmania normally contains limestone which often overlaps the basal conglomerates and rests on the Dundas Group. Perhaps the most likely interpretation therefore is that this crinoidal limestone should be correlated with the Junee Group of Ordovician Age. For the present however neither hypothesis can be substantiated or excluded.

Relation of Basic Volcanic Rocks and Tillite of Western Tasmania to Dundas Group

In the Zeehan, Smithton, and King Island areas we have an old series of basic amygdaloidal lavas which have many petrological features in common. The King Island occurrence is approximately 80 miles north-west of Smithton which in turn is 70 miles north of Zeehan. In between, petrologically similar rocks occur at Magnet. The King Island and Zeehan occurrences are underlain by tillites containing striated pebbles. At Smithton the lavas are underlain by a silicified breccia lithologically similar to phases of the King Island Tillite. At King Island the glacial

beds and volcanic rocks are partly interbedded. At Zeehan the slates and tuffs immediately and conformably overlying the volcanic rocks contain Middle Cambrian trilobites indentical with those occurring in the type area of the Dundas Group, eight miles to the east. In the type Dundas sequence there is a suite of lavas and tuffs petrologically similar to those at King Island and the other localities. These are interstratified with Middle Cambrian fossils. Also interstratified with fossilferous Middle Cambrian beds in the type Dundas section are conglomerates and breccias which one of us (S.W.C.) and independently Elliston (who worked out the type section) consider to resemble tillites, but no unquestionable striated pebbles have yet been extracted from them. However there are some striated pebbles preserved in the Museum of the Geology Department in the Adelaide University, which were collected by Waller from near Montezeuma Falls, Dundas, and along the north-east Dundas tramline, and forwarded by Waller to Howchin for confirmation of their glacial origin. Although the recorded localities are not precise enough to pinpoint which of the conglomerates yielded the striated pebbles, Elliston's mapping has revealed that all the rocks outcropping in the area where these striated pebbles were collected belong to the Middle Cambrian Dundas Group.

Integrating all the above evidence it is difficult to escape the conclusion that the glacial beds as well as the basic lavas belong to the Dundas Group and are of Cambrian Age.

This raises again questions about the age of the glaciation in the Adelaide Group of South Australia which has latterly been regarded as late Pre-Cambrian. It is of interest to note that near Broken Hill the Torrowangie Group, which contains a basal tillite, has breccias and greywackes strikingly reminiscent of the Dundas Group; also that basic lavas petrologically similar to the Dundas Lavas have recently been reported in the Torrowangie Group which recalls an earlier record of basic lavas by E. J. Kenny. A close search of this sequence for Cambrian dendroids and trilobites seems warranted.

References

Nye, P. B., Finucane, K. J., Blake, F., 1934.—The Geology of the Smithton District, Bull. 41. *Geol. Surv. Tas.*

Scott, Beryl, 1951.—The Petrology of the Volcanic Rocks of South-East King Island, Tasmania. *Pap. & Proc. Roy. Soc. Tas.*, 1951, pp. 113-136.

Locality Index

	Latitude S.	*Longitude E.*
Broken Hill	32° 0′	141° 30′
Coward's Road	40° 51′	145° 8′
Deep Creek	40° 49′	145° 10′
Duck Bay	40° 50′	145° 4′
Dundas	41° 53′	145° 28′
Fahey's Lane	40° 54′	145° 11′
Groom's Road	40° 54′	145° 8′
King Island	39° 35′	143° 50′
Irishtown	40° 54′	145° 9′
Magnet	41° 28′	145° 26′
Montezeuma Falls	41° 50′	145° 27′
Nabageena	40° 59′	145° 8′
Park Point	40° 49′	145° 8′
Queenstown	42° 5′	145° 33′
Smithton	40° 52′	145° 7′
Tier Hill	40° 52′	145° 8′
Torrowangie	31° 28′	141° 29′
Trowutta	41° 0′	145° 4′
Zeehan	41° 53′	145° 20′

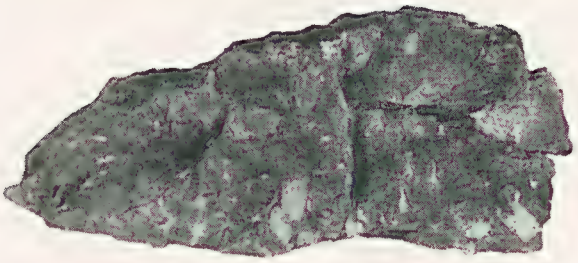


FIG. 1 x 0·4

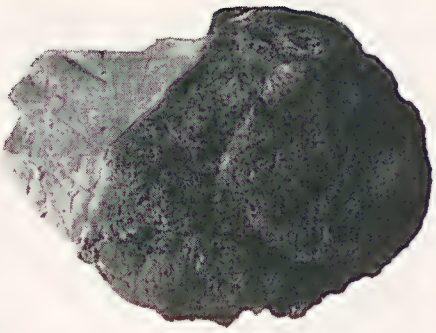


FIG. 2 x 0·35

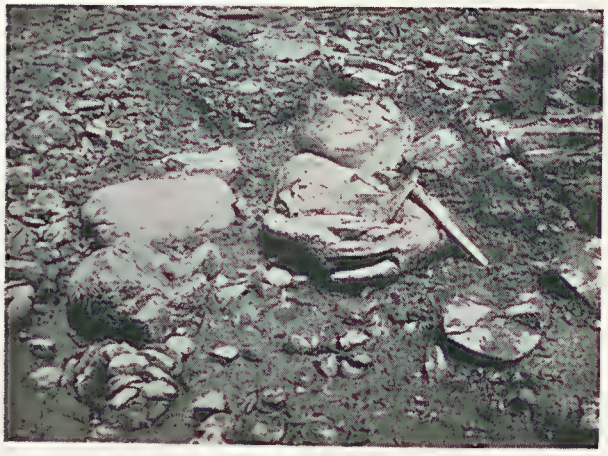


FIG. 3

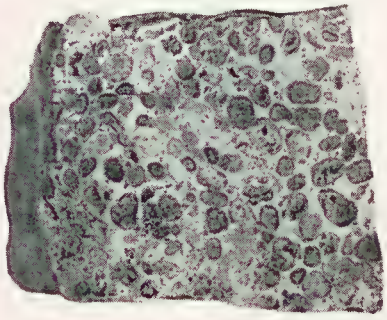


FIG. 4 x 0·75

Explanation of Plates

Plate I.

Figure 1: Volcanic breccia, the lava fragments of which are depicted by the lighter colour and the chocolate shale by the darker colour.

Figure 2: Volcanic bomb showing its shape and vesicular nature. Note its sharp boundary with the shale.

Figure 3: Pillows of lava. See text figure 1, for explanation.

Figure 4: Silicified oolite showing the oval shaped oolites which vary in colour. The light coloured material between them is composed of very fine granular quartz.

Plate II.

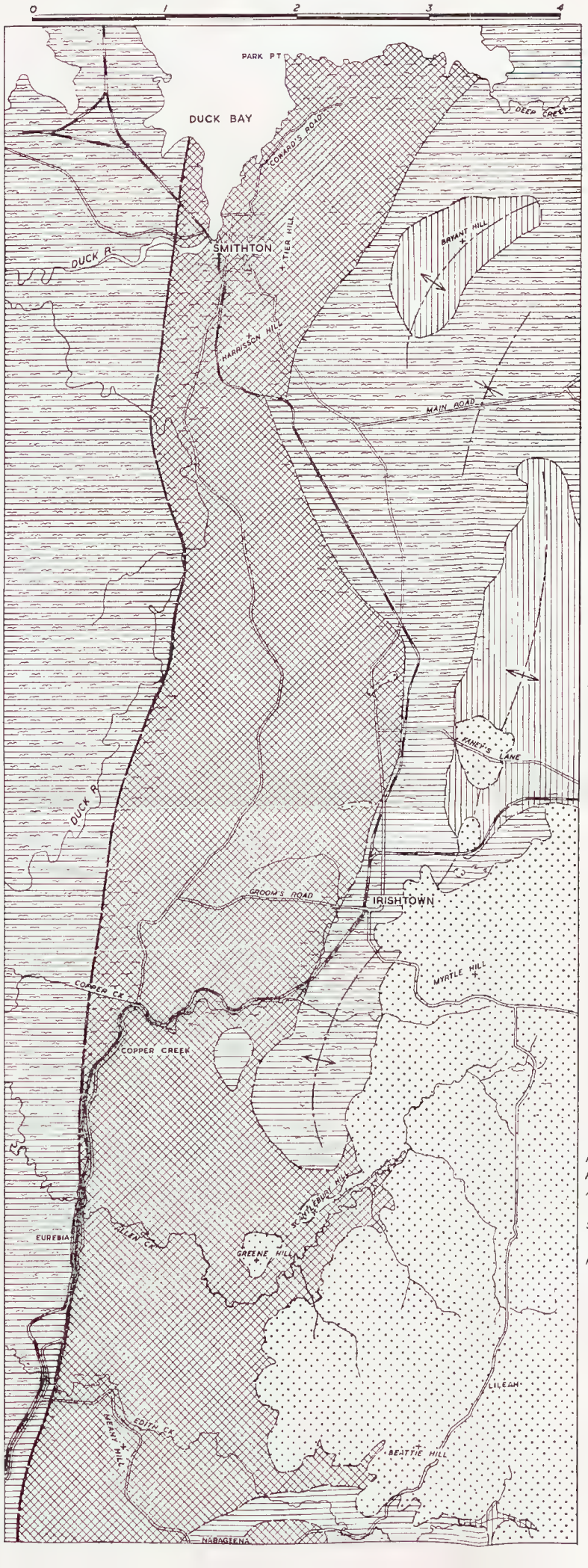
Geological Map of the Smithton District of Tasmania.

GEOLOGY OF THE SMITHTON DISTRICT — TASMANIA

REVISED INTERPRETATION
BY CAREY–SCOTT BASED ON FIELD MAPPING BY GEOLOGICAL SURVEY OF TASMANIA

— SCALE OF MILES —

0 1 2 3 4



LEGEND

Quaternary
ALLUVIUM AND SWAMP DEPOSITS

Tertiary
BASALTS

Cambrian
DUNDAS GROUP

Pre-Cambrian
CARBINE GROUP
SMITHTON DOLOMITE

SMITHTON DOLOMITE UNDER ALLUVIUM

BRYANT HILL QUARTZITE

TRUE NORTH
MAGNETIC NORTH 9·25° E OF N

ROADS
RAILWAYS
ANTICLINAL AXIS
SYNCLINAL AXIS
PROBABLE FAULT

The Marine Algae of Tasmania Check List with Localities

By

Eric R. Guiler

(Zoology Department, University of Tasmania)

Introduction

In the course of ecological studies undertaken recently it has been found necessary to identify numerous seaweeds and a great need has been felt for an up-to-date list of the species recorded from Tasmania. In order to diminish this gap in our literature the following list has been prepared. The species have been recorded both from the literature and the collection.

The most recent list of Tasmanian seaweeds is that published by Lucas in 1928. This list was incomplete in many respects as the author did not include many species preserved in the Rodway Herbarium, and in many records Lucas did not give any clue as to the locality in which he found the species. Since 1928 many changes in nomenclature have taken place and these complicate the identification from the earlier works.

Lucas recorded 418 species. The present list contains about 130 species which were not in Lucas's list as well as a great number of new locality records.

The late Mrs. Perrin contributed the names of several species which are new to Tasmania as well as a high proportion of new locality records. Mr. A. Cribb has identified species for me as well as donated specimens to the University Herbarium. He has also provided me with much valuable guidance on synonymy and without his help this work would never have been completed. Professor V. J. Chapman sent me a list of some species which are recorded from Tasmania and Miss L. B. Moore of the D.S.I.R. of New Zealand has revised the Sphacelariaceae.

The species are listed with the localities at which they have been found and the name of the person responsible for the record is also given. If the record was published the date of publication is given after the author's name. For the sake of brevity this date has been omitted from all references to the list published by Lucas and Lucas & Perrin. Also in the interests of brevity several author's names have been reduced to initials. These are as listed below:—

L.	= Lucas, 1928
R.	= Rodway (Herbarium)
L.A.M.	= Mrs. Meredith
P.B.	= Miss Batt (Private collection)
P.	= Mrs. Perrin
L. & P.	= Lucas & Perrin, 1936
H.N.B.	= Professor Barber
H.D.G.	= Professor Gordon
H.	= Harvey (Phycologica Australis)

I would like to thank Professor H. N. Barber for the use of facilities in the Botany Department of the University of Tasmania.

SIPHONALES VALONIACEAE

Dictyosphaeria Decaisne

D. sericea Harv. — Mouth of R. Derwent (R.) ; Northern Tasmania (L., 1936) ; Currie R. (P.).

CAULERPACEAE

Bryopsis Lamouroux

B. plumosa (Huds.) Ag. — Passim (L.) ; Bicheno, Low Head, Adventure Bay (P.) ; Huon River (R.) ; Orford (L.A.M.).

B. hypnoides Lamour. — Eaglehawk Neck (R.).

B. australis Sond. — P. Arthur, 1/1951 (Cribb).

CAULERPACEAE

Caulerpa Lamouroux

C. annulata Lucas — Port Arthur (Cribb).

C. brownii Endl. — Passim (L.) ; Maria Is., 1915 (R.) ; Raminea, Southport (R.) ; Orford (L.A.M.) ; Tasmania (L., 1936) ; Currie R. (9/1950, Cribb) ; Marrawah, Cape Grim, Musselroe Bay, Currie R. (P.).

C. cactoides (Turn.) Ag. — Passim (L.) ; Actaeon Is. (R.) ; Tasmania (L., 1936) ; Currie R, 9/1950 (Cribb) ; Currie R., Musselroe Bay, Adventure Bay (P.).

C. flexilis Lamour. — No locality (L.).

C. hypnoides (R. Br.) Ag. — No locality (L.) ; Low Head (P.) ; Tasmania (L.) ; Adventure Bay, 4/1947 (P.B.) ; Currie R. (Cribb).

C. hypnoides var. *Muelleri* — Passim (L.) ; Orford (L.A.M.) ; Low Head, Currie R., Eddystone Pt., Devonport (P.).

C. longifolia Ag. — Orford (L.A.M.) ; Tasmania (L., 1936) ; N. Coast (L.) ; Maria Is., Barnes Bay (R.) ; Oyster Bay (L., 1915) ; Southport (L., 1936) ; Currie R. (P.).

C. longifolia var. *crispata* (Harv.) — Norm. Pitt Water, 11/1950 (Cribb) ; Tasmania (Gunn).

C. obscura Sond. — North Coast (L.) ; Tasmania (L., 1936) ; Bass Strait and Tasmania (Harv.) ; Currie R. and Low Head (P.).

C. scalpelliformis (R. Br.) Ag. — Maria Is., Shot Tower (R.) ; Tasmania (L., 1936) ; Tamar (Harv.) ; Coles Bay, Cape Grim, Currie R., Triabunna (P.).

C. sedoides (R. Br.) Ag. — Passim (L.) ; Tasmania (L., 1936) ; Blackman's Bay (H.N.B.) ; Currie R., 9/1950, P. Arthur, 6/1951 (Cribb) ; Currie R., Cape Grim, P. Arthur, Low Head.

C. simpliciuscula (Turn.) Ag. — No locality (H.D.G.) ; Blackman's Bay (H.N.B.) ; Tasmania (L., 1936) ; Currie R., Musselroe Bay (P.).

C. simpliciuscula var. *vesiculifera* — Tasmania (L., 1938 & 1936) ; Currie R. (P.).

C. trifaria Harv. — Port Esperance, Channel (L.); Orford (L.A.M.); Derwent R., Maria Is. (R.); Oyster Bay (L., 1915); Marrawah (P.); Port Arthur 6/1951 (Cribb).

DASYCLADACEAE

Polyphysa Lamouroux

P. peniculata Ag. — Boomer Marsh, 1949 (Dr. Curtis).

CODIACEAE

Codium Stackhouse

C. bursa (L.) Ag. — R. Derwent (L.); Bellerive (R.); Low Head, Currie R. (P.). Confused with other species (Cribb).

C. decorticatum (Woodward) Howe — Tasmania (L., 1936); Currie R. (P.).

C. fragile (Suringar) Hinot — Blackman's Bay (H.N.B.); Taroona (P.B., 1946); Low Head, Currie R., Marrawah (P.); Bellerive (R.); Passim (L.).

C. galeatum J. Ag. — Shot Tower and Derwent R. (R.).

C. lucasii Setchell — Tasmania (L., 1936).

C. muelleri Kütz. — North Coast (L.); Tasmania (L., 1936); Orford, 1876 (L.A.M.); Low Head, Marrawah (P.).

C. perrinae Lucas — Low Head (Cribb).

C. spongiosum Harv. — North Coast (L., 1936); Currie R. (P.).

C. tomentosum (Huds.) Stack. — No locality (R.); Oyster Bay (L., 1915); Tasmania (L.). Professor Chapman suggests that this species is probably *C. fragile* or *C. mucronatum*, and Mr. Cribb states that this species is confused with one of the others.

PHAEOPHYTA

ISOGENERETAE *ECTOCARPALES* ECTOCARPACEAE

Ectocarpus Lyngbye

E. confervoides (Roth.) Le Jol. — Channel (R.); On *Epymenia*, Pt. Puer, 1/1951 (Cribb).

E. fasciculatus (Griff.) Harv. — Tasmania (Harv.); no locality (L.); on *Zostera* at Low Head, 9/1950; on *Macrocystis* at Pt. Puer, 6/1951 (Cribb).

E. siliculosus (Dillw.) Lyngb. — No locality (L.).

E. sordidus Harv. — George Town (Harv.); Low Head (P.).

Pylaiella Bory

P. littoralis (L.) Kjell. — Southport, 9/1950 (Cribb).

SPHACELARIALES STYPOCAULACEAE

Halopteris Kützing

H. hordacea (Harv.) Sauv.	Low Head, Currie River, Eddystone Point, Marrawah and Bicheno (Perrin); Blackman's Bay, Derwent Estuary (Perrin per L.B. Moore); Southport (Stuart).
H. funicularius (Mont.) Sauv.	Burnie, Low Head and Bridport (Lucas); Orford and Southport (Melbourne Herbarium); Taroona (H.D.G.; Taroona (L. B. Moore); all these records were supplied by Miss Moore.
H. pseudospicata Sauv.	Currie River (Perrin & Lucas); Emu Bay (Melbourne Herb.); Currie River, Burnie, Devonport; Eaglehawk Neck (L. B. Moore). All these records were supplied by Miss Moore.
Stypocaulon (*Halopteris*) *paniculatum* (Suhr.) Kütz.	Miss Moore states that this species is covered in part by *H. hordacea*. Rodway records *S. paniculatum* from Shot Tower, Derwent and Devonport. Miss P. Batt has a specimen from Taroona, 7/1946.

Phloeocaulon Geyler

P. spectabile Reinke	Low Head (Lucas); Wynyard (Perrin); Miss Moore states that some or all of these specimens are labelled *Xanthosiphonia wattsii* in error.

Xanthosiphonia J. Ag.

X. wattsii J. Ag.	East beach at Low Head, Marrawah (Perrin). These records do not include those noted by Miss Moore as being in error.

Ptilopogon Reinke

P. botrycadus H.f. & H.) Reinke	Drift at Taroona (L. B. Moore).

CLADOSTEPHACEAE

Cladostephus Ag.

C. spongiosus (Lightf.) Ag.	Passim (L.); Low Head (H.D.G.); Port Arthur, 6/1951 (Cribb); Southport, Derwent and Devonport (R.).
C. verticillatus (Lightf.) Ag.	Tasmania (Stuart).

CUTLERIALES CUTLERIACEAE

Cutleria Greville

C. multifida Greville	No locality (R. & L.).

DICTYOTALES DICTYOTACEAE

Dictyota Lamouroux

D. bifurca J. Ag.	Southport (R.).
D. dichotoma (Huds.) Lamouroux	Passim (L.) ; Currie River, Low Head, Marrawah, Montagu, Eddystone Pt. (P.) ; Sandy Bay (A. M. Olsen).
D. diemenensis Sond.	George Town (H.) ; Channel (R.) ; Port Arthur, 1/1950 (Cribb).
D. furcellata C. Ag.	Tasmania (Fereday).
D. nigricans J. Ag.	Orford (L.A.M.).
D. noevosa Suhr.	George Town (H.).
D. ocellata J. Ag.	No locality (L.).
D. vittariodes J. Ag.	King Island (Mrs. Spong) ; Tasmania (L., 1936) :

Pachydictyon J. Ag.

P. paniculatum J. Ag.	Orford (L.A.M.) ; Passim (L.).

Dilophus J. Ag.

D. fasciculatus J. Ag.	No locality (L.).
D. gunnianus J. Ag.	No locality (L.).
D. taeniaeformis J. Ag.	Low Head (L.).

Dictyopteris Lamouroux

D. muelleri (Sond.) Schmitz	Taroona, 2/1951 (Cribb).

Lobospira Areschoug

L. bicuspidata Aresch.	Oyster Bay (Lucas, 1915).

Dictyopteris Web. & Mohr.

D. muelleri (Sond.) Schmidt	Tasmania (H.) ; Maria Is. (R.) ; Orford (L.A.M.) ; Tasmania (L., 1936) ; Low Head, Currie River, Swansea, Adventure Bay (P.) ; Blackman's Bay (H.N.B.).
D. aerostichoides (J. Ag.) Boergesen	No locality (L.) ; Tasmania (L., 1936).

ZONARIEAE

Pocockiella Papenfuss

P. variegata (Lamour.) Papenfuss	Channel (R.) ; Eaglehawk Neck (P.).

Zonaria Ag.

Z. subarticulata (Lamour.) Papenfuss	Orford (L.A.M.) ; Devonport, Derwent and Channel (R.) ; Tasmania (L., 1936) ; Tasmania (H.) ; Low Head, Currie River, Eddystone Pt. and Montagu (P.) ; Taroona, 4/1946 (P.B.).
Z. stuposa R. Br.	Kent Is. (L.) ; Tasmania (L., 1936).

HETERGENERATAE *CHORDARIALES* MYRIONEMATACEAE

Myrionema Greville

M. strangulans (Grev.) — Frequent on *Ulva* (L.); Derwent (R.); Low Head, Bridport (P.); On *Ulva* at Southport, 10/1951 (Cribb).

ELACHISTACEAE

Elachista Duby

E. australis J. Ag. — Derwent (R.).

CORYNOPHLAEACEAE

Leathesia Gray

L. diffiformis (L.) Aresch. — Low Head; Ulverstone (L.); Tasmania (L., 1936).

CHORDARIACEAE

Chordaria Ag.

C. dictyosiphon (Harv.) Kütz. — Channel (R.); Passim (L.); George Town (H.).

Cladosiphon Kützing

C. vernicularis (J. Ag.) Kylin — Eaglehawk Neck (R.).

Eudesme J. Ag.

E. harveyana Kylum. — George Town (Gunn).

Myriogloia Kuckuck

M. sciurus (Harv.) Kuck. — Derwent (R.); George Town (H.); Bicheno, 1/1952 (H.N.B.).

Polycerea J. Ag.

P. nigrescens (Harv.) Kylim — No locality (L.).

Suringaria Kylin

S. harveyana (J. Ag.) Kylin — Ulverstone (L.).

Tinocladia Kylin

T. australis (Harv.) Kylin — Low Head, Orford (L.).

SPERMATOCHNACEAE

Stilopsis Kockuck

S. harveyana Kylin — George Town (H.).

SPLANCHNIDIACEAE

Splanchnidium Greville

S. rugosum (L.) Grev. — Thouin Bay (R.); George Town (H.); Low Head and Currie River (P.).

DICTYOSIPHONALES PUNCTARIACEAE

Adenocystis Hooker F. & Harv.

A. utricularis (Bory) Skottsberg — Port Arthur (J.); Eaglehawk Neck (H.N.B. & E.R.G.); Orford, Currie River (P.); Safety Cove, Trial Harbour (E.R.G.).

SPOROCHNALES SPOROCHNACEAE

Bellotia Harvey

B. eriophorum Harv. — North Coast (L.); Dredged, 20 fathoms near Actaeon Is. (R.); Cambridge (R.); Bass Strait (L., 1936); Eddystone Point and Currie River (P.).

Carpomitra Kützing

C. mitriformis — Tasmania (L., 1936).

Nereia Zanardini

N. australis Harv. — Widely distributed (L.); Tasmania (L., 1936).

Perithalia J. Ag.

P. inermis (R. Br.) J. Ag. — Shot Tower and Devonport (R.); Port Arthur (Stuart); Passim (L., 1915); Ralph's Bay, 2/1948 (P.B.); Port Arthur, 10/1951 (Cribb); Low Head, Currie River, Musselroe Bay, Eddystone Point, Wynyard, Cape Grim, Marrawah (P.).

Sporochnus Agardh

S. apodus Harv. — George Town (L.).

S. comosus Ag. — Passim, especially the North Coast (L.); Muddy Plains (R.); Tasmania (L., 1936); Low Head and Currie R. (P.).

S. herculeus J. Ag. — George Town (L.).

S. radiciformis (R. Br.) Ag. — Derwent and Maria Is. (R.); Tasmania (L., 1936); Low Head, George Town (P.); Orford (L.A.M.).

DICTYOSIPHONALES PUNCTARIACEAE

Adenocystis Hooker F. & Harv.

A. utricularis (Bory) Skottsberg — Port Arthur (J.); Eaglehawk Neck (H.N.B. & E. R. G.); Orford, Currie River (P.); Safety Cove, Trial Harbour (E.R.G.).

Asperococcus Lamouroux

A. bullosus Lamour. — Passim (L.); Channel and Eaglehawk Neck (R.); Tasmania (L., 1936); Low Head (P.).

Colpomenia Derbes & Solier

C. sinuosa (Roth.) Derb. & Sol. — Passim (L.); Bellerive (R.); Low Head (P.)

Ilea J. Ag.

I. fascia (Muell.) Fris. — Tamar (L.).

Scytosiphon Agardh

S. lomentaria (Lyng.) J. Ag. — Passim (L.); Derwent (R.); Tasmania (L., 1936); Howrah, Eaglehawk Neck, Dover Blackman's Bay (E.R.G.); Low Head (Cribb). This species forms a winter growth on the shore.

Stictyosiphon Kützing

S. decaisnei (H. & H.) Murray — Lucas (no locality); Orford (L.A.M.).

CHNOOSPORACEAE

Scytothamnus Hooker F. & Harvey

S. australis (J. Ag.) H. & H. — Low Head (L.).

LAMINARIALES LESSONIACEAE

Lessonia Bory

L. corrugata Lucas — Thouin Bay (R.); Bicheno, Orford, Adventure Bay, Marrawah; Cape Grim, Eddystone Pt. (P.); Betsy Is.; Blackman's Bay (E.R.G.).

Macrocystis Ag.

M. pyrifera (L.) Agardh — Passim (L.); Tasmania (L., 1936); Derwent, Huon and Thouin Bay (R.); Low Head, Wynyard, Devonport (P.); Safety Cove (H.D.G.); East Coast, Port Arthur (E.R.G.).

ALARIACEAE

Ecklonia Horneman

E. radiata (Ag.) J. Ag. — Passim (L.); Tasmania (L., 1936); Blackman's Bay (H.D.G.); Derwent (R.); Low Head, Currie River, Adventure Bay, Cape Grim, Marrawah, Eddystone Pt. (P.); Eaglehawk Neck, Dover (E.R.G.).

CYCLOSPOREAE *FUCALES* DURVILLACEAE

Durvillea Bory

D. antarctica (Cham.) Hariot. — Drift, Port Arthur, 1/1950 (Cribb); Drift, Taroona, 1/1949 (Moore).

Sarcophycus Kützing

S. potatorum (Labill.) Kütz. — Channel (R.); Safety Cove (H.D.G.); Tasmania, all coasts (L., 1936). This record of all coasts is not correct. The species is confined to wave-exposed places. Rodway's record for the Channel is also dubious as the only part of the Channel in which I have found this species is Roaring Beach, near Dover, where it occupies a very restricted area. Eaglehawk Neck, Sleepy Bay, Remarkable Cave, Point Seymour, Trial Harbour (E.R.G.).

Hormosira Endlicher

H. banksii (Turn.) Decaisne — Channel, Maria Is., Thouin Bay, Southport (R.); Tasmania (H.); Safety Cove (H.D.G.); Low Head, Montagu, Marrawah (P.); Blackman's Bay; Trial Harbour, Betsy Is., Dover, Eaglehawk Neck, Coles Bay, Boat Harbour (N. Coast), Burnie, Devonport, (E.R.G.); Boomer Marsh (Curtis). This species is found on practically all shores of Tasmania, but it only rarely forms a Hormosiretum, e.g., Point Puer.

Notheia Bailey & Harvey

N. anomala Bailey & Harvey — On *Hormosira* from Thouin Bay (R.); Tasmania (L., 1936); Port Arthur (Cribb); Currie River, Cape Grim, Musselroe Bay (P.).

FUCACEAE

Myriodesma Decaisne

M. integrifolia Harv. — Ulverstone, Tamar (L.); Tasmania (L., 1936).

Phyllospora Ag.

P. comosa (Labill.) Ag. — Devonport, Mouth of Huon River, Thouin Bay, Woody Is. (R.); Tasmania (L., 1936); Tasmania (H.); Port Arthur (Cribb); Low Head, Currie River, Montagu, Marrawah (P.); Eaglehawk Neck, Sleepy Bay, Point Seymour, Trial Harbour (E.R.G.).

Scytothalia Greville

S. dorycarpa (Turn.) Grev. — Kent Is. (L.); Tasmania and Tamar Heads (L., 1936); Low Head (P.).

Seirococcus Greville

S. axillaris (R. Br.) Grev. — Orford (L.A.M.); Passim (L.); Channel and Devonport (R.); Tasmania (L., 1936); Coles Bay (H.N.B.); Tasmania (H.); Low Head, Currie River, Cape Grim, Marrawah, Musselroe Bay, Eddystone Pt. (P.).

Xiphophora Montague

X. billardieri Mont. — Channel, Derwent and Bellerive (R.); Blackman's Bay (H.N.B.); Tasmania (L., 1936); Port Arthur (Cribb); Bicheno, Marrawah (P.); Eaglehawk Neck (E.R.G.).

X. chondrophylla (R. Br.) Mont. — Devonport (R.); Tasmania (L., 1936); Adventure Bay, 4/1947 (P.B.); Low Head, Currie River (P.); George Town (Gunn); Eaglehawk Neck (E.R.G.).

CYSTOSEIRACEAE

Carpoglossum Kützing

C. confluens (R. Br.) Kütz. — Derwent and Channel (R.); George Town (Gunn); Port Dalrymple (H.); Tasmania (L., 1936); Low Head, Currie R., Marrawah, Cape Grim (P.); Blackman's Bay (H.N.B.).

Cystophora J. Ag.

C. cephalornithos (Lab.) J. Ag. — Maria Is., Barnes Bay (R.); Tasmania (L., 1936); South Arm (P.B.); Orford (L.A.M.); Blackman's Bay (H.N.B.).

C. grevillei (Ag.) J. Ag. — Southport (R.); Tasmania and Oyster Bay (L., 1915); Tasmania (L., 1936); East Coast (P.).

C. monilifera J. Ag. — Tasmania (L., 1936).

C. paniculata (Turn.) J. Ag. — Orford (L.A.M.); Low Head (H.D.G.); Derwent, Bellerive, Channel (R.); Tasmania (L., 1936); Blackman's Bay (H.N.B.); Currie River, Adventure Bay, Cape Grim, Marrawah, Musselroe Bay (P.); Port Arthur, 10/1951 (Cribb).

C. platylobium (Mert.) J. Ag. — Tasmania (L., 1936); Adventure Bay (4/1947, P.B.); Low Head, Currie R., Cape Grim, Marrawah, Eddystone Pt., Adventure Bay (P.).

C. polycystidea Aresch. — Tasmania (L., 1936).

C. retorta (Mert.) J. Ag. — Tasmania (L.); Low Head, Currie River (P.); George Town (Gunn).

C. retroflexa (Labill.) J. Ag. — Passim (L.); Bellerive, Devonport and Barnes Bay (Rodway); Tasmania (L., 1936); Low Head, Currie River (P.).

C. scalaris J. Ag. — No locality (L.).

C. siliquosa J. Ag. — Burnie (L.); Tasmania (L., 1936).

C. spartioides (Turn.) Ag. — Devonport (R.); Tasmania (L., 1936); Blackman's Bay (H.N.B.); Low Head, Currie River (P.); Grange, Eaglehawk Neck, Safety Cove (E.R.G.).

C. subfarcinata (Mert.) J. Ag. — Tasmania (L., 1936).

C. torulosa (R. Br.) J. Ag. — Devonport, Southport, Derwent (R.); Swansea (L.); Tasmania (L., 1936); Tasmania (H.); Blackman's Bay (H.N.B.); Port Arthur, 3/1950 (Cribb); Low Head, Currie River, Musselroe Bay, Eddystone Pt. (P.); Orford (L.A.M.); Coles Bay (E.R.G.).

C. uvifera (Ag.) J. Ag. — Tasmania (H.); Devonport and Maria Is. (R.); Oyster Bay and Tasmania (L., 1915); Low Head Currie River, Eddystone Pt., Cape Grim (P.).

C. xiphocarpa Harv. — Port Arthur (Harv.); Muddy Plains (R.); Brown's River and Southport (L.); Blackman's Bay (H.N.B.); Marrawah, Cape Grim, Bicheno, Orford (P.).

Cystophyllum J. Ag.

C. muricatum (Turn.) J. Ag. — No locality (L.); Tasmania (L., 1936); George Town (Gunn).

SARGASSACEAE

Sargassum Ag.

S. bracteolosum J. Ag. — Burnie (L.); Tasmania (L., 1936).

S. decipiens (R. Br.) J. Ag. — South Arm (L.).

S. decurrens (R. Br.) Ag. — No locality (L., 1938).

S. grande J. Ag. — Port Esperance (L.); Low Head (P.); Port Arthur, 10/1951 (Cribb).

S. gunnianum J. Ag. — Low Head (L.).

S. heteromorphum J. Ag. — Low Head (L.); Currie River (P.).

S. lacerifolium (Turn.) Ag. — Tamar (L., 1936).

S. laevigatum J. Ag. — No locality (L.).

S. linearifolium (Turn.) J. Ag. — Ralph's Bay (R.). [Probably an incorrect determination (Cribb).]

S. membranaceum J. Ag. — No locality (L.).

S. muriculatum J. Ag. — Tasmania (L.); King Island (Mrs. Spong).

S. paradoxum (R. Br.) Harv. — Orford (L.A.M.); Bellerive, Channel (R.); Low Head (H.D.G.); Currie River, Musselroe Bay, Eddystone Pt. (P.); Tasmania (H.); Sandy Bay (Dr. Lyall); Southport (Stuart); George Town (Gunn); Port Arthur (H.).

S. rhyncophorum J. Ag. — No locality (L.).

S. sonderi J. Ag.	Low Head, Derwent (L.) ; Orford (P.).
S. undulatum J. Ag.	Tasmania and Oyster Bay (L., 1915).
S. varians Sonder	Low Head (L.), (H.D.G.) ; Currie River (P.).
S. verruculosum (Mert.) Ag.	Shot Tower, Ralph's Bay, Thouin Bay (R.) ; Channel, Port Esperance (L.) ; Port Arthur, Oyster Bay (L., 1915) ; Thouin Bay, Low Head (H.D.G.) ; Montagu (P.) ; Tasmania (H.) ; Sandy Bay (Dr. Lyall) ; Southport (Stuart) ; George Town (Gunn) ; Port Arthur (H.).
S. vestitum (R. Br.) Ag.	Kent Is.; Burnie, Derwent (L.).

Scaberia Greville

S. agardhii Greville	North Coast (L.) ; Tasmania (H.) ; Tasmania (L., 1936) ; Tasmania and Oyster Bay (L., 1915) ; Low Head, Currie River, Devonport, Wynyard, Stanley (P.).

RHODOPHYTA

BANGIOIDEAE *BANGIALES* BANGIACEAE

Bangia Lyngbye

B. atropurpurea (Roth.) Ag.	Derwent and Blackman's Bay (R.).
B. ciliaris subspecies *pulchella* Harv.	George Town (H.).
B. fuscopurpurea (Dillw.) Lyngb.	Southport, 10/1951 (Cribb).

Porphyra Ag.

P. columbina Mont.	Howrah, Eaglehawk Neck, Blackman's Bay, Dover (E.R.G.). Identified by H. B. S. Womersley.
P. umbilicalis (L.) J. Ag.	Southport, 6/1951 (Cribb) ; Bellerive (R.) ; Passim (L.) ; Sandy Bay (R.) ; Low Head, Bicheno (P.).
P. woolhousiae Harv.	On *Macrocystis* (H.).

FLORIDEAE *NEMALIONALES* BONNEMAISONIACEAE

Asparagopsis Montagne

A. armata Harv.	Devonport, Tamar, Low Head, Middleton (P.) ; Eaglehawk Neck (L.) ; Tasmania (Gunn) ; Tasmania (L. & P.).

Delisea Lamouroux

D. elegans (Ag.) Mont.	North Coast, Derwent (R.) ; Low Head, Currie River, Eddystone Pt., Musselroe Bay, Adventure Bay (P.) ; Port Arthur, 1/1951 (Cribb) ; Tasmania (Levring, 1946).

D. hypneoides Harv. — Tamar, Low Head (P.) ; George Town (H.).
D. pulchra (Grev.) Mont. — Port Arthur (H.) ; Port Arthur, 2/1950 (Cribb).
D. serrata Kütz. — Huon River (R.).

Ptilonia J. Ag.

P. australasica Harv. — Tasmania (L. & P.) ; Oyster Bay (L., 1915) ; Port Esperance (L.) ; Low Head, Currie River, Cape Grim, Eddystone Pt. (P.).
P. intermedia Lucas — Channel (R.) ; Low Head, Musselroe Bay, Eddystone Pt. (P.) ; Orford, 6/1950 (Cribb).
P. sabulifera J. Ag. — Tasmania (Lodder).

Leptophyllis J. Ag.

L. conferta (R. Br.) J. Ag. — Southport (Stuart) ; Southport (R.) ; Kent Is. (Brown) ; Tasmania (L. & P.) ; George Town (Gunn) ; Southport, 10/1951 (Cribb).

HELMINTHOCLADIACEAE

Batrachospermum Roth

B. dillenii Bory — Esk River (L.) ; Mt. Field Plateau (R.).
B. moniliforme Roth — Lake Leila, Cradle Mountain (R.).
B. vagum Ag. — No locality (L.).

Liagora Lamouroux

L. harveyana Zeh. — North Tasmania (L. & P.) ; George Town (H.).
L. wilsoniana Zeh. — Tasmania (L. & P.).

Helminthocladia J. Ag.

H. densa (Harv.) Schmitz — Tamar, Ulverstone, Kelso, Currie River (P.) ; Tasmania (L. & P.) ; George Town (Gunn).

CHAETANGIACEAE

Gloiophloea J. Ag.

G. scinaioides J. Ag. — Tamar, George Town, Derwent (Cribb).

Chaetangium Kützing

C. lingula Harv. — Brown's River (Gunn) ; Huon River (R.) ; Eaglehawk Neck (L.).
C. flabellatum Harv. — Port Arthur (H.).

Gelidium Lamouroux

G. australe J. Ag. — No locality (L.) ; Low Head, Cape Grim, Currie River, Eddystone Pt. (P.) ; Port Arthur, 2/1950 (Cribb).
G. glandulaefolium H. & H. — Circular Head, Southport (H.) ; Tasmania (L. & P.) ; Low Head, Currie River, Devonport, Wynyard, Cape Grim (P.).

Pterocladia J. Ag.

P. lucida (R. Br.) J. Ag. — No locality (Univ. Herb.) ; Cape Grim, Marrawah, Bicheno, Eddystone Pt. (P.).

CRYPTONEMIALES DUMONTIACEAE

Dasyphloea Montagne

D. tasmanica Harv. — Circular Head (H.) ; Tasmania (L. & P.) ; Low Head (P.) ; Stewart's Bay, 6/1951 (Cribb).

SQUAMARIACEAE

Ethelia W. von Bosse

E. australis (Sond.) W. v. Bosse — Bass Strait (H.) ; Sandy Bay (R.) ; Tasmania (L. & P.) ; Blackman's Bay, 4/1948 (H.N.B.) ; Eddystone Pt., Currie River, Marrawah (P.).

Peysonnelia Decaisne

P. gunniana J. Ag. — George Town (H.).

CORALLINACEAE CORALLINEAE

Amphiroa Lamouroux

A. tasmanica Sond. — No locality (L.).

Corallina Linnaeus

C. cuvieri Lamour. — Tasmania (L. & P.) ; Passim (L.) ; Shot Tower, Actaeon Is., Blackman's Bay (R.) ; Low Head, Currie R., Marrawah, Cape Grim, Eddystone Pt. (P.) ; Pt. Puer, 2/1952 (Cribb).

C. denudata Sond. — Triabunna, 3/1950 (Cribb).

C. officinalis L. — Bellerive (R.) ; Passim (L.) ; Low Head, Currie River (P.) ; Pt. Puer, 3/1951 (Cribb).

C. pilifera Lamour. — Oyster Bay (Lucas, 1915) ; Southport, 10/1951 (Cribb).

Melobesia Lamouroux

M. tasmanica (Fosl.) de Toni — Tasmania.

Jania Lamouroux

J. micrarthrodia Lamouroux — Channel (R.) ; Tasmania (L. & P.) ; On *Zostera* Port Arthur, 2/1950 (Cribb) ; On *Zostera*, Stewart's Bay, 1/1951 (Cribb) ; Low Head, Currie River (P.).

J. natalensis Harv. — Triabunna, 3/1950 (Cribb).

Metagoniolithon W. von Bosse

M. charoides (Lamour.) W. v. Bosse — North Coast (L.) ; Actaeon Is. (R.) ; Tasmania (L. & P.) ; Triabunna, 3/1950 (Cribb).

M. stelligera (Lam.) W. v. Bosse — Tasmania (H.); Oyster Bay (Lucas, 1915); Passim (L.); Tasmania (L. & P.); Currie R., 9/1950 (Cribb).

Cheilosporum Decaisne

C. elegans (H. & H.) Aresch. — George Town (Gunn).

Arthrocardia Decaisne

A. mallardiae (Harv.) Aresch. — Passim (L.).

A. wardii (Harv.) Aresch. — Tasmania (L. & P.).

MASTOPHOREAE

Metamastophora Setchell

M. canaliculata (Harv.) Setchell — Tasmania (Stuart); Tasmania (L. & P.).

M. flabellata (Sond.) Setchell — Passim (L.); Shot Tower (R.).

LITHOTHAMNIEAE

Lithothamnion Philippi

L. muelleri Lenorm. — On *Gelidium australe*, Port Arthur, 3/1950 (Cribb).

L. patena (H. & H.) Heydrich — On *Ballia callitricha*, Port Arthur, 10/1951 (Cribb).

Lithophyllum Philippi

L. hyperellum Foslie — Pt. Puer, Eaglehawk Neck, Trial Harbour, Sleepy Bay (E.R.G.). Identified by H. B. S. Womersley.

GRATELOUPIACEAE

Halymenia Ag.

H. chondropsidea J. Ag. — No locality (L.).

H. speciosa Zan. — George Town (Mrs. Goodwin).

Grateloupia Ag.

G. dubia Zan. — Hobart (L.).

G. filicina (Wulf.) Ag. — Passim (L.); Sandy Bay (R.); Tasmania (L. & P.); Low Head, 9/1950, Bellerive, 3/1950 (Cribb).

G. prolifera J. Ag. — Tasmania (L. & P.); Taroona, 9/1946 (P.B.).

Pachymenia J. Ag.

P. apoda J. Ag.	No locality (L.); Tasmania (L. & P.).
P. orbicularis (Zan.) S. & G.	Tasmania (Cribb).

Prionitis J. Ag.

Prionitis sp.	Eddystone Pt., Musselroe Bay (P.).

Polyopes J. Ag.

P. constrictus (Turn.) J. Ag.	Port Arthur, 10/1951 (Cribb).

Carpopeltis Schmitz

C. phyllophora (H. & H.) Schmitz	Port Arthur (Jeanneret); Southport (Stuart).

Thamnoclonium Kützing

T. claviferum J. Ag.	Tasmania (H.); Tasmania (L. & P.); Actaeon Is. (R.); Ralph's Bay, 2/1948 (P.B.); Passim (L.); Currie R., Devonport, Marrawah (P.).

CALLYMENIACEAE

Callophyllis Kützing

C. coccinea Harv.	Passim (L.); Bellerive (R.); Oyster Bay (Lucas, 1915); Tasmania (L. & P.); Adventure Bay, 4/1947 (P.B.); Low Head, Currie River, Devonport, Wynyard, Montagu, Musselroe Bay, Eddystone Pt., Swansea, Bicheno, Adventure Bay, Middleton, Dover (P.); Port Arthur, 10/1951, and 1/1951, Southport, 10/1951 (Cribb).
C. fimbriata H. & H.	George Town (Gunn).
C. harveyana J. Ag.	No locality (L.); Tasmania (L. & P.).
C. lambertii (Turn.) Grev.	North Coast (L.); Shot Tower (R.); Orford (L.A.M.); Tasmania (L. & P.); Low Head, Currie River, Eddystone Pt., Adventure Bay (P.).
C. lingulata J. Ag.	Tasmania (Gunn).
C. microcarpa Zan.	George Town (Goodwin).

Callymenia J. Ag.

C. cribrosa Harv.	Tamar (Fereday); Tasmania (L. & P.); East Coast (Gunn); Orford (L.A.M.); Musselroe Bay, Adventure Bay (P.).
C. tasmanica Harv.	Tamar (H.); Orford (L.A.M.); Tasmania (L. & P.); Currie River, Musselroe Bay, Eddystone Pt., Adventure Bay (P.).

Polycoelia J. Ag.

P. fastigiata Harv.	Tamar (H.) ; Orford (L.A.M.) ; Musselroe Bay, Currie River (P.).
P. laciniata J. Ag.	Low Head (L. & P.) ; Adventure Bay (P.).

Meredithia J. Ag.

M. polycoelioides J. Ag.	Orford (L.A.M.) ; Tasmania (L. & P.).

GIGARTINALES NEMASTOMACEAE

Nemastoma J. Ag.

N. feredayae Harv.	George Town (Mrs. Fereday) ; Tasmania (L. & P.) ; Low Head, Currie River, Swansea (P.).
N. palmata Harv.	Tasmania (L. & P.) ; Swansea (P.).

GRACILARIACEAE

Curdiea Harvey

C. laciniata Harv.	Orford (L.A.M.) ; Rare in Tasmania (L. & P.) ; Eddystone Pt., Cape Grim, Musselroe Bay (P.).
C. meredithiae J. Ag.	Orford (L.A.M.).

Trematocarpus Kützing

T. concinnus (R. Br.) J. Ag.	Kent Islands (R. Br.).

Gracilaria Greville

G. confervoides (L.) Grev.	Tasmania (L. & P.) ; Derwent (R.), (L.) ; Pt. Arthur, 1/1951 (Cribb) ; Bridport (P.).
G. flagellifera J. Ag.	Sandy Bay (R.).
G. lichenoulis (L.) Harv.	Ralph's Bay, 1940 (Univ. Herb.) ; Tamar, Middleton, Adventure Bay (P.).
? G. spinescens (Kütz.) J. Ag.	No locality (L.).

Melanthalia Montagne

M. obtusata (Labill.) J. Ag.	Tasmania (Gunn) ; Remine and Devonport (R.) ; Tasmania (L. & P.) ; Currie River, Eddystone Pt., Bicheno, Orford, Adventure Bay, Cape Grim (P.) ; Port Arthur, 10/1951 (Cribb).

Calliblepharis Kützing

C. planicaulis (Harv.) Kylin	George Town (H.).

PLOCAMIACEAE

Plocamium Lamouroux

P. costatum (J. Ag.) H. & H.	Passim (L.) ; Adventure Bay, 4/1947 (P.B.) ; Maria Is., Oyster Bay (Lucas, 1915) ; Devonport (R.) ; Low Head, Eddystone Pt., Currie River (P.).

P. coccineum v. *flexuosum* Harv. — Port Arthur, 3/1950 (Cribb); Passim (L.); Low Head, Musselroe Bay, Eddystone Pt. (P.).

P. dilatatum J. Ag. — No locality (L.).

P. mertensii (Grev.) Harv. — Passim (L.); Derwent (R.); Low Head (P.).

P. patagiatum J. Ag. — Tasmania (L.); Low Head, George Town (P.).

P. procerum (J. Ag.) Harv. — Passim (L.); Tasmania (H.); Shot Tower (R.); Eddystone Pt., Musselroe Bay, Flinders Is., Tamar (P.).

P. telfairiae Harv. — Tasmania (L. & P.); No locality (L.); Passim (L.); Adventure Bay, 4/1947 (P.B.); Maria Is. (R.); Devonport, Southport and Ralph's Bay (Univ. Herb.). This species was recorded as *P. angustum* and *P. gracile* by Lucas. Low Head, 9/1950 (Cribb); Tasmania (Levring, 1946).

Phacelocarpus Endlicher and Diesing

P. alatus Harv. — Southport (R.).

P. complanatus Harv. — Southport (Stuart); Tasmania (L. & P.); Musselroe Bay, Eddystone Pt., Cape Grim (P.); Tasmania (Levring, 1946).

P. labillardieri (Mert.) J. Ag. — Passim (L.); South Arm, 7/1946 (P.B.); Tasmania (H.); Devonport (R.); Tasmania (L. & P.); Low Head, Currie River, Eddystone Pt., Bicheno, Swansea, Orford, Adventure Bay, Cape Grim, Marrawah, Cape Sorell (P.); Port Arthur, 10/1951 (Cribb).

SARCODIACEAE

Nizymenia Sonder

N. australis Sond. — Southport (Stuart); Gordon, Eddystone Pt., Currie River (P.); Tasmania (L. & P.).

SOLIERIACEAE

Solieria J. Agardh

S. robusta (Grev.) Kylin — Ralph's Bay (R.); Tasmania (L. & P.); George Town (H.); Low Head, Currie River, George Town, Devonport (P.); Tasmania (Levring, 1946).

S. compressa (J. Ag.) Kylin — No locality (L.); Tasmania (Levring, 1946).

RHABDONIACEAE

Areschougia Harvey

A. laurencia (H. & H.) Harv. — Orford (L.A.M.); Tasmania (L. & P.); Low Head, Currie River (P.); George Town (Gunn).

A. stuartii Harv. — Southport (Stuart; Port Esperance (L.).

Erythroclonium Sonder

E. muelleri Sond. — Actaeon Is. (R.) ; Orford (L.A.M.) ; Tasmania (L. & P.) ; Currie River (P.) ; Taroona, 2/1951 (Cribb).

Rhabdonia Harvey

R. coccinea Harv. — George Town (H.) ; Devonport (R.) ; Tasmania (L. & P.) ; Low Head, Adventure Bay (P.).

R. dendroides Harv. — Tasmania (L. & P.).

R. mollis (Harv.) Lucas — George Town (P.).

R. nigrescens Harv. — No locality (L.) ; Tasmania (L. & P.) ; Low Head, Currie River, Montague (P.) ; George Town (H.).

R. umbellata Zan. — No locality (L.) ; Ulverstone, Musselroe Bay (P.).

R. verticillata Harv. — George Town (H.) ; Channel, Ralph's Bay (R.) ; Tasmania (L. & P.) ; Orford (L.A.M.) ; Low Head, Currie River, Devonport, Wynyard (P.).

RHODOPHYLLIDACEAE

Rhodophyllis Kützing

R. goodwiniae J. Ag. — Tamar (Mrs. Goodwin) ; Tasmania (L. & P.).

R. gunnii Harv. — Tamar (L.) ; Channel (R.) ; Tasmania (L. & P.) ; Orford (L.A.M.) ; Taroona (H.D.G.) ; Currie River, Eddystone Pt., Adventure Bay, Middleton (P.) ; Southport, 10/1951 (Cribb) ; Tasmania (Levring, 1946).

R. membranacea Harv. — No locality (L.) ; Tasmania (L. & P.) ; Low Head, Montague, Currie River, Musselroe Bay, Eddystone Pt. (P.) ; George Town (Gunn) ; Southport (Stuart).

R. multipartita Harv. — No locality (L.) ; Port Arthur (Lyall) ; Port Arthur (H.) ; Low Head, Currie River, Eddystone Pt., Musselroe Bay, George Town (P.).

Meristotheca J. Agardh

M. tasmanica J. Ag. — Orford (L.A.M.).

HYPNEACEAE

Hypnea Lamouroux

H. episcopalis H. & H. — Passim (L.) ; Tasmania (H.) ; Tasmania (L. & P.) ; Low Head, Currie River, Montagu, Devonport (P.).

H. musciformis (Wulf.) Lamour. — George Town (Gunn).

H. seticulosa J. Ag. — Passim (L.) ; Tasmania (L. & P.) ; Low Head, Cape Grim, Currie River (P.).

Rhododactylis J. Ag.

R. bulbosa (Harv.) J. Ag. — No locality (L.); East Coast of Tasmania (Gunn); Derwent (Oldfield).

MYCHODEACEAE

Mychodea Harvey

M. carnosa Harv. — Tamar (L.); George Town (H.), (Gunn); Derwent (R.); Cape Grim, Musselroe Bay, Eddystone Pt., Montagu (P.); Lewisham, 11/1950 (Cribb).

M. disticha Harv. — Derwent (R.); East Coast (Gunn).

M. hamata Harv. — Passim (L.); Low Head, George Town, Currie River (P.); Port Arthur, 10/1951 (Cribb); Tasmania, George Town, Port Arthur (H.).

M. membranacea Harv. — Orford (L.A.M.).

M. terminalis Harv. — George Town (H.).

Gymnogongrus Martius

G. fastigiatus Harv. — Forester's River (Gunn); Eaglehawk Neck (P.).

Ectoclinium J. Ag.

E. dentatum J. Ag. — No locality (L.); Tasmania (Gunn); Low Head (Cribb).

Stenogramma Harvey

S. interrupta (Ag.) Mont. — Bellerive (R.); mouth of Derwent (L.); George Town, Port Arthur (H.); Tasmania (L. & P.); Eaglehawk Neck (P.).

ACROTYLACEAE

Acrotylus J. Ag.

A. australis J. Ag. — Tasmania (H.); Tasmania (L. & P.); Musselroe Bay, Eddystone Pt., Cape Grim, Marrawah (P.).

GIGARTINACEAE

Gigartina Stackhouse

G. aciculifera Zan. — Derwent (R.).

G. ancistroclada Mont. — Mouth of Derwent (Gunn, Rodway); Brown's River (Gunn); Bellerive (R.); Musselroe Bay, Eddystone Pt. (P.).

G. binderi Harv. — Hobart, Burnie (L.).

G. brachiata Harv. — George Town (H.); Orford (L.A.M.).

G. congesta Zan. — No locality (L.); Hobart (Cribb).

G. crassicaulis (J. Ag.) S. & G. — Passim (L.); Bellerive (R.); Tasmania (H.); Huon River (R.); Orford (L.A.M.); Tasmania (L. & P.); Low Head, Eddystone Pt., Cape Grim, Marrawah (P.).

G. gigantea J. Ag.	No locality (L.); Tasmania (L. & P.); Swansea, Adventure Bay, Eddystone Pt. (P.).
G. muelleriana S. & G.	Tasmania (L. & P.); Musselroe Bay, Eddystone Pt., Marrawah, Cape Grim (P.); Low Head, 1944 (H.D.G.).
G. pinnata S. & G.	Swansea (P.).
G. radula (Esp.) J. Ag.	Orford (L.A.M.); Eddystone Pt. (P.).
G. wehliae Sond.	Hobart (Melb. Herb.).

Rhodoglossum J. Ag.

R. prolifera J. Ag.	No locality (L.).

Iridaea Bory

I. australasica (J. Ag.) Lucas & Perrin	No locality (L.); Tasmania (L. & P.); Low Head (P.).
I. folifera Harv.	No locality (L.); George Town (P.); George Town (Gunn).
I. harveyi J. Ag.	No locality (L.); George Town (Gunn).
I. polycarpa Harv.	No locality (L.); Low Head (P.); Stewart's Bay, 6/1951 (Cribb).
I. purpurea J. Ag.	No locality (L.); Low Head (P.).
? I. latissima (H. & H.) Grunow	No locality (L.); Orford (L.A.M.).

DICRANEMACEAE

Dicranema Sonder

D. grevillei Sonder	Flinders Is. (H.).

RHODYMENIALES RHODYMENIACEAE FAUCHEAE

Bindera Harvey

B. splanchnoides Harv.	N. Tasmania (L. & P.); Bellerive (R.); George Town (Archer); Musselroe Bay, Currie River (P.); George Town (H.).

Gloioderma J. Ag.

G. australis J. Ag.	No locality (L.); E. Coast (Gunn); Currie R. Eddystone Pt., (P.).
G. fruiticulosum (Harv.) de Toni	Tasmania (L. & P.).
G. speciosa (Harv.) J. Ag.	Low Head (P.); George Town (Goodwin).
G. wilsonis (J. Ag.) de Toni	Currie River, Eddystone Pt. (P.); Tasmania (L. & P.).

RHODYMENIEAE

Botryocladia Kylin

B. obovata (Sond.) Kylin	George Town (Harv.), (L.).

Chrysymenia J. Ag.

C. coccinea Harv. — Van Diemen's Land (H.) ; George Town (H.).

Sebdenia Berthold

S. kallymenioides (Harv.) de Toni — Orford (L.A.M.).

Sebdenia sp. — Adventure Bay, Bellerive (P.).

Erythrymenia Schmitz

E. meredithiana (J. Ag.) Kylin — Orford (L.A.M.).

Gloiosaccion Harvey

G. brownii (Harv.) J. Ag. — Tamar, Ulverstone, Channel (L.) ; Tasmania (L. & P.) ; Mouth of Derwent and Huon Rivers, Maria Is., Channel (R.) ; Orford (L.A.M.) ; Blackman's Bay, 4/1948 (H.N.B.).

Epymenia Kützing

E. cuneata (Harv.) J. Ag. — East Coast (Gunn) ; Port Esperance (L.).

E. halymenioides J. Ag. — Channel (L.) ; Orford (L.A.M.).

E. membranacea Harv. — Southport (Stuart) ; George Town (H.).

E. wilsonis Sond. — Port Arthur, 10/1951 (Cribb).

Rhodymenia Greville

R. corallina (Bory) Grev. — George Town (Gunn).

R. foliifera Harv. — Channel (R.) ; Orford (L.A.M.), 10/1951 (Cribb).

R. linearis J. Ag. — No locality (L.) ; Low Head, Currie River, Eddystone Pt. (P.).

R. pinnulata Zan. — No locality (L.) ; George Town (Goodwin).

R. prolificans Zan. — No locality (L.) ; George Town (Goodwin).

Hymenocladia J. Ag.

H. polymorpha (Harv.) J. Ag. — Flinders Is. (H.) ; George Town (H.). Tasmania (L. & P.) ; Low Head, Adventure Bay, Eddystone Pt. (P.).

CHAMPIACEAE CHAMPIEAE

Champia Desveau

C. affinis (H. & H.) J. Ag. — George Town (H.) ; No locality (L.).

C. insignis Lucas — Derwent Estuary (L. & P.).

C. obsoleta Harv. — George Town, Southport (Stuart) ; Derwent (R.) ; Stewart's Bay, 6/1951, Southport, 10/1951 (Cribb) ; Low Head (P.).

C. parvula (Ag.) — No locality (L.) ; George Town (H.).

C. tasmanica Harv. — Blackman's Bay, Bellerive, Southport (R.); Low Head, Eddystone Pt., Musselroe Bay, Cape Grim (P.).

Chylocladia Greville

C. clavellosa (Turn.) Grev. — George Town (H.).

CERAMIALES CERAMIACEAE GRIFFITHSIAE

Griffithsia C. Ag.

G. antarctica H. & H. — Brown's River (Gunn; George Town (H.).

G. flabelliformis Harv. — George Town (Gunn); No locality (L.); Tasmania (L. & P.).

G. gracilis Harv. — George Town (H.); Low Head (P.).

G. grandis — Middleton (P.).

G. gunniana J. Ag. — No locality (L.); Tasmania (L. & P.); Tasmania (Levring, 1946).

G. monilis Harv. — Bellerive (R.); Tasmania (L. & P.); Port Arthur, 10/1951 (Cribb).

G. ovalis Harv. — Coles Bay, 2/1950 (H.N.B.).

MONOSPOREAE

Neomonospora Setchell & Gardner

N. arachnoides (Harv.) Womersley — No locality (L.); George Town (H.).

N. elongata (Harv.) Womersley — Tasmania (L. & P.); No locality (L.); Low Head, George Town, Musselroe Bay, Eddystone Pt., Currie River (P.); George Town (Gunn).

N. griffithsioides (Sond.) Womersley — Orford (L.A.M.); George Town (Gunn); Derwent, Huon, Bellerive, Southport (R.); Tasmania (L. & P.).

Bornetia Thuret

B. meredithiana J. Ag. — Orford (L.A.M.); Tasmania (L. & P.); Southport, 10/1951 (Cribb).

Pleonosporium Naegeli

P. comatum (J. Ag.) de Toni — No locality (L.); Tasmania (L. & P.).

SPERMOTHAMNIEAE

Spermothamnion Areschoug

S. turneri (Mert.) Aresch. — No locality (L.).

CALLITHAMNIEAE

Callithamnion Lyngbye

C. fastigiatum Harv. — George Town (Gunn); Low Head, Currie R., Musselroe Bay, Bridport (P.).

C. corymbosum (Smith) C. Ag. — On shells, *Posidonia*, &c., at Low Head, 9/1950, on shells, tube worms, at Spring Bay, 6/1951 (Cribb).

C. laricinum Harv. — Port Arthur (H.); Tasmania (L. & P.).

Seirospora Harvey

S. byssoides de Toni var. *caulescens* J. Ag. — No locality (L.).

SPONGOCLONIEAE

Haloplegma Montagne

H. preisii Sond. — Orford (L.A.M.); North Coast (L.); Low Head, Currie River, Eddystone Pt., Marrawah (P.); Taroona, 1/1948 (P.B.).

Spongoclonium Sonder

S. angustatum (H. & H.) de Toni — George Town (H.).

S. latissimum (H. & H.) de Toni — North Coast (L.); George Town (Gunn); Low Head, George Town, Bell Bay (P.).

S. paradoxum (Harv.) de Toni — Derwent (L.); Sandy Bay (R.); Tasmania (L. & P.); Pilot Station, Derwent, 2/1950 (Cribb).

S. scoparium J. Ag. — Orford (L.A.M.).

S. violaceum (Harv.) de Toni — Tamar (H.); Derwent (L.).

S. wilsonianum J. Ag. — George Town (P.).

S. wollastonianum J. Ag. — Low Head (P.).

Warrenia Kützing

W. comosa Harv. — Derwent and Muddy Plains Beach (R.); Tamar (H.); Tasmania (Gunn, (L. & P.); Low Head, George Town, Pt. Effingham (P.).

PTILOTEAE

Euptilota Kützing

E. articulata (J. Ag.) Schmitz — Passim (L.); George Town (Gunn); Tasmania (L. & P.); Low Head, Currie River, Musselroe Bay, Eddystone Pt., Adventure Bay (P.); Tasmania (Levring, 1946).

E. coralloidea (J. Ag.) Schmitz — King Island (Mrs. Spong); Tasmania (L. & P.); Low Head, Currie River (P.).

E. jeannerettii (Harv.) Schmitz — Orford (L.A.M.); Port Arthur (Jeannerett); Southport (Stuart); Tasmania (Harv.), (L. & P.).

Rhodocallis Kützing

R. elegans Kütz. — Southport (Stuart); Actaeon Is. (R.); Tasmania (L. & P.); Blackman's Bay, 4/1948 (H.N.B.); Orford, 10/1951 (Cribb).

DASYPHILEAE

Dasyphila Sonder

D. preissii Sonder — Tasmania (L. & P.).

Muellerena Schmitz

M. insignis (Harv.) de Toni — Ulverstone (L.) ; Derwent (R.) ; Tasmania (L. & P.) ; Low Head, Currie River (P.).

Gulsonia Harvey

G. annulata (Harv.) — George Town (Gunn) ; Low Head, Currie River (P.).

CROUANIEAE

Antithamnion Naegeli

A. dispar (Harv.) J. Ag. — East Coast (Gunn) ; Tasmania (L. & P.).

A. divergens (J. Ag.) de Toni — George Town (Gunn, (H.) ; Tasmania (L. & P.) ; Swansea (P.).

A. flaccidum (H. & H.) de Toni — Tasmania (Gunn).

A. mucronatum (J. Ag.) de Toni — Passim (L.) ; Channel (R.) ; Tasmania (L. & P.) ; Low Head, George Town, Currie River, Eddystone Pt., Middleton (P.) ; George Town (Gunn).

A. nodiferum J. Ag. — Port Arthur (L.).

A. plumula (Ellis) Thuret — George Town (H.) ; Derwent (L.) ; Tasmania (L. & P.).

Ballia Harvey

B. callitricha (Ag.) Mont. — Tasmania (L. & P.) ; Orford (L.A.M.) ; King Is., Derwent and Remine (R.) ; Passim (L.) ; Adventure Bay, 4/1947 (P.B.) ;; Blackman's Bay, 2/1948 (H.N.B.) ; Low Head, Cape Grim, Marrawah, Eddystone Pt., (P.) ; Port Arthur 10/1951 (Cribb).

B. mariana Harv. — Eddystone Pt., Cape Grim (P.) ; Port Arthur, 10/1951 (Cribb).

B. robertiana Harv. — Southport (Stuart) ; Tasmania (L. & P.) ; Eddystone Pt., Cape Grim, Sorell (P.) ; Port Arthur, 10/1951 (Cribb).

B. scoparia Harv. — King Is., Remine (R.) ; Port Arthur (L.) ; Blackman's Bay, 2/1948 (H.N.B.) ; Tasmania (L. & P.).

Crouania J. Ag.

C. australis (Harv.) L. Ag. — Table Cape (H.) ; Low Head (L.) ; Tasmania (L. & P.).

C. gracilis J. Ag. — No locality (L.).
C. hanowoides (Sond.) de Toni — On *Gelidium australe*, Pt. Puer, 2/1952 (Cribb).
C. mucosa Womersley — Among *Zostera*, Low Head, 9/1950 (Cribb).
C. muelleri Harv. — Currie River (P.).
C. vestita Harv. — Bicheno (P.).

Lasiothalia Harvey

L. hirsuta Harv. — Ulverstone (L.); Tasmania (L. & P.); Low Head, George Town (P.); Tasmania (Levring, 1946).

SPYRIDIEAE

Spyridia Harvey

S. biannulata J. Ag. — No locality (L.); Tasmania (L. & P.); Low Head (P.).
S. breviarticulata J. Ag. — No locality (L.).
S. filamentosa (Wulf.) Harv. — George Town (Univ. Herb.); Port Arthur, 6/1950 (Cribb).
S. opposita Harv. — Tasmania (L. & P.); Southport (Stuart); Derwent (R.).

CERAMIEAE

Centroceras Kützing

C. clavulatum (Ag.) Mont. — Passim (L.); Port Esperance, Eaglehawk Neck (R.); Orford (L.A.M.); Port Arthur, 1/1951 (Cribb); Bicheno, 10/1951 (Cribb).

Ceramium Wiggers

C. aequabile J. Ag. — Passim (L.); Low Head, Bridport (P.); George Town (Gunn); Orford (L.A.M.).
C. deslongchampii Chauv. — No locality (L.).
C. divergens J. Ag. — Tasmania (L.); Currie River (P.).
C. excellens J. Ag. — Derwent (L.); Tasmania (L. & P.).
C. fastigiatum Harv. — On *Zostera*, Port Arthur, 10/1951 (Cribb).
C. gracillimum Griff. & Harv. — George Town (H.); Tasmania (L. & P.).
C. isogonum Harv. — Tasmania (L. & P.).
C. monacanthum J. Ag. — Derwent (R.).
C. nobile J. Ag. — Derwent (L.), (R.); Tasmania (L. & P.); Low Head, George Town (P.).
C. puberulum Sond. — Tamar (L.); Tasmania (L. & P.); Low Head, George Town (P.), (Gunn).
C. ramulosum H. & H. — Tamar (Gunn).
C. stichidiosum J. Ag. — No locality (L.).

C. subcartilagineum J. Ag. — Passim (L.) ; Tasmania (L. & P.) ; Low Head, Musselroe Bay, Eddystone Pt. (P.).
C. tenuissimum (Lyngb.) J. Ag. — Tasmania (H.).
C. torulosum J. Ag. — Maria Is., Derwent (R.).

Thamnocarpus Harvey

T. gunnianus Harv. — George Town (H.) ; Tasmania (L. & P.).
T. harveyanus J. Ag. — No locality (L.).

Microcladia Greville

M. pinnata J. Ag. — Tasmania (Levring, 1946).

WRANGELIEAE

Wrangelia Ag.

W. ballioides J. Ag. — Tasmania (L. & P.) ; Tamar, Low Head, Montagu, Cape Grim, Eddystone Pt. (P.).
W. crassa H. & H. — George Town (Gunn) ; Tasmania (L. & P.).
W. gunniana J. Ag. — No locality (L.).
W. jeanneretti H. & H. — Port Arthur (H.).
W. mucronata Harv. — Tasmania (L. & P.) ; Currie River, Musselroe Bay (P.).
W. nobilis Harv. — Tamar (H.) ; Port Esperance (L.) ; Tasmania (L. & P.) ; Orford (L.A.M.) ; Low Head (P.) ; Low Head, 9/1950 (Cribb) ; Orford, 10/1951 (Cribb).
W. plumosa Harv. — D'Entrecaseaux Channel (R.) ; Passim (L.) ; Tasmania (L. & P.) ; George Town (Gunn) ; Flinders Is., Low Head, Ulverstone, Bicheno, Adventure Bay (P.).
W. protensa Harv. — George Town (H.) ; Tasmania (L. & P.) ; Low Head, Musselroe Bay, Currie River (P.).
W. setigera Harv. — George Town (Gunn), (H.).
W. velutina Harv. — Tasmania (Levring, 1946).
W. verticillata Harv. — Tasmania (L. & P.) ; Musselroe Bay, Currie R. (P.).

DASYACEAE

Dasya C. Ag.

D. capillaris H. & H. — Tamar (H.) ; Channel (R.) ; Low Head, 1944 (H.D.G.) ; Tasmania (L. & P.) ; George Town (P.).
D. ceramioides Harv. — Huon River, Actaeon Is. (R.) ; Tasmania (L. & P.) ; Low Head, George Town, Gordon (P.).
D. elongata Sond. — Tasmania (Levring, 1946).
D. feredayae Harv. — George Town (Mrs. Fereday) ; Derwent (R.) ; Low Head, Currie River (P.).
D. haffiae Harv. — Table Cape (H.) ; George Town (Gunn) ; Tasmania (L. & P.) ; Low Head (P.).

D. hapalathrix Harv.	George Town and Pt. Rapid (H.); Tasmania (L. & P.).
D. meredithiae J. Ag.	Low Head, Currie River (P.); Taroona, 9/1946 (P.B.).
D. naccarioides Harv.	Passim (L.); Tasmania (L. & P.); Cape Portland, George Town, Low Head, Currie River, Musselroe Bay, Eddystone Pt. (P.); George Town (Gunn); Port Arthur, 1/1951 (Cribb).
D. tasmanica Sond.	George Town (H.); Low Head, Currie River (P.).
D. urceolata Harv.	Derwent (R.); Tasmania (L. & P.).
D. villosa Harv.	Passim (L.); Barnes Bay, Ralph's Bay (R.); Tasmania (L. & P.); Bell Bay, Tamar, Kelso, Currie River, Eddystone Pt., Montagu, Adventure Bay (P.).

Halodictyon Zanardini

H. arachniodeum Harv.	Tasmania (L. & P.); Coles Bay (P.).

Heterosiphonia Montagne

H. archeri (Harv.) de Toni	George Town (Archer).
H. gunniana (Harv.) Falk.	Passim (L.); Tasmania (L. & P.); Low Head, 1944 (H.D.G.); George Town, Middleton (P.).
H. microcladioides (J. Ag.) Falk.	George Town (Gunn).
H. muelleri (Sond.) de Toni	Ulverstone, Tamar, Musselroe Bay, Low Head (P.); Tasmania (H.), (L. & P.).
H. struthiopenna (J. Ag.) de Toni	No locality (L.); Low Head, George Town (P.).
H. wrangelioides (Harv.) Falk.	Low Head, 9/1950 (Cribb).

Thuretia Decaisne

T. quercifolia Decaisne	Flinders Is., Musselroe Bay (P.).

DELESSERIACEAE DELESSERIEAE

Apoglossum J. Ag.

A. ruscifolium (Turn.) J. Ag.	Tamar (L.); Very doubtful (Cribb).
A. tasmanicum (F. v. M.) J. Ag.	Ralph's Bay, Barnes Bay (R.); Tamar (Harv.); Port Esperance (L.); Tasmania (L. & P.); Low Head (P.).

Claudea Lamouroux

C. elegans Lamour.	George Town (L.); Tamar (H.), (Fereday), (L. & P.).

Hemineura Harvey

H. frondosa Harv.	Derwent, Sandy Bay (R.); Passim (L.); Tasmania (H.), (L. & P.); Low Head, 9/1950 (Cribb); Port Arthur, 2/1952 (Cribb); Musselroe Bay, Eddystone Pt., Middleton (P.).
H. wilsonia J. Ag.	Tamar (L.).

Halicnide J. Ag.

H. similans J. Ag.	Tamar (H.); No locality (R.).

Hypoglossum Kützing

H. heterocystideum J. Ag.	Channel (R.).
H. spathulatum (Kütz.) J. Ag.	Tamar (P.).

Phitymophora J. Ag.

P. imbricata (Aresch.) J. Ag.	Passim (L.); Sandy Bay (R.); Tasmania (L. & P.).

Sarcomenia Sonder

S. corymbosa J. Ag.	Low Head, Currie River (P.).
S. dasyoides Harv.	Ulverstone (L.).
S. tenera (Harv.) J. Ag.	Low Head, Currie River (P.).
S. victoriae (Harv.) J. Ag.	Low Head, Gordon (P.).

Sonderella Schmitz

S. linearis (Sond.) Schmitz	Tamar (Quaife).

Caloglossa Harvey

C. leprieurii (Mont.) J. Ag.	Tasmania, estuaries (L. & P.); no locality (L.).

NITOPHYLLEAE

Cryptopleura Kützing

C. endiviaefolia (H. & H.) Kylin	No locality (L.).

Hymenena Greville

H. affinis (Harv.) Kylin	Retreat (R.).
H. curdiana (Harv.) Kylin	Tamar (L.).
H. multipartita (H. & H.) Kylin	No locality (L.).

Nitophyllum Greville

N. crispum (Kütz.) J. Ag.	North Coast (L.) ; Low Head, 9/1950 (Cribb) ; Tasmania (Levring, 1946).
N. hymenema Zan.	Hobart (Cribb).
N. obseletum Zan.	George Town (Goodwin).
N. perrinae Lucas	George Town (L. & P.).
N. polyanthum J. Ag.	No locality (L.).
N. uncinatum (Turn.) J. Ag.	George Town, Low Head (P.).

Mesotrema J. Ag.

M. australis (Harv.) Pap.	Tasmania (Gunn), (H.).
? M. gigas (Harv.) Pap.	Tamar (H.).

Platyclinia J. Ag.

P. stipitata (Harv.) J. Ag.	Tasmania (L. & P.) ; Tasmania (L.).

Myriogramme Kylin

M. gattyana (J. Ag.) Kylin	Derwent (R.).
M. gunniana (Harv.) Kylin	George Town (Gunn) ; Tasmania (L. & P.) ; Orford, 6/1950, and 1/1952 (Cribb) ; Tasmania (Levring, 1946).

RHODOMELACEAE POLYSIPHONIEAE

Chiracantha Falkenberg

C. arborea (Harv.) Falk.	George Town (H.) ; Tasmania (L. & P.) ; Currie River (P.).
C. valida (J. Ag.) Falk.	Low Head, 9/1950 (Cribb).

Pithyopsis Falkenberg

P. tasmanica (Sond.) Falk.	George Town (H.) ; Currie River (P.).

Bryocladia Schmitz

B. ericoides (Harv.) Schmitz	Eaglehawk Neck (L.) ; Port Arthur, Tasmania (H.) ; Port Arthur, 1/1951 (Cribb).

Lophurella Schmitz

L. hookeriana (J. Ag.) Falk.	Port Arthur, 2/1951 (Cribb).
L. periclados (Sond.) Schmitz	Derwent (R.) ; Brown's River (Gunn) ; Southport (H.) ; Channel (R.) ; Tasmania (L. & P.) ; Low Head, Currie River (P.).

Falkenbergia Schmitz

F. vagabunda (Harv.) Falk. — Eaglehawk Neck (H.) ; Tasmania (L. & P.).

Polysiphonia Greville

P. abcissa H. & H. — Ulverstone, Port Esperance (L.) ; Tasmania (L. & P.) ; Low Head, Flinders Is. (P.) ; Bellerive, 3/1950, Southport, 10/1951 (Cribb).

P. caespitula Sonder — Eaglehawk Neck (R.).

P. cancellata Harv. — Shot Tower (R.) ; Bellerive, Tasmania (L. & P.) ; Low Head (P.) ; Tasmania (Levring, 1946).

P. crassiuscula Harv. — East Coast (Gunn), (L. & P.).

P. dasyoides Zan. — George Town (L. & P.).

P. ferulacea Suhr. — Table Cape (Miss Mackenzie) ; Burnie (Carter) ; both quoted by Lucas, 1928. Tasmania (L. & P.).

P. flavescens Zan. — George Town (L. & P.).

P. frutex Harv. — Derwent (R.) ; Tasmania (L. & P.) ; Low Head and all parts of Tasmania (P.).

P. fuscescens Harv. — Port Arthur, 1/1951, and 3/1950, Dover, 3/1951 (Cribb).

P. hookeri Harv. — Tasmania (L. & P.) ; Passim (L.) ; Taroona, 1/1948 (P.B.) ; Channel (R.) ; Low Head, Montagu, Middleton, Bellerive, Currie River, Musselroe Bay (P.) ; Pittwater, 12/1951, Lewisham, 11/1950, Port Arthur, 1/1952, Taroona, 1/1951, Southport, 10/1951 (Cribb).

P. hystrix H. & H. — Passim (L.) ; Tasmania (L. & P.) ; Low Head, Currie River, Eddystone Pt., Musselroe Bay, Montagu (P.) ; Tasmania (Levring, 1946).

P. laxa Harv. — East Coast (Gunn) ; Tasmania, on *Zostera* (L. & P.).

P. longissima J. Ag. — Derwent (R.).

P. macarthra Zan. — George Town (Goodwin).

P. mallardiae Harv. — Snug (L.) ; Devonport (R.) ; Low Head (P.).

P. mollis H. & H. — Passim (L.) ; Actaeon Is., Risdon, Sandy Bay (R.) ; Tasmania (L.) ; George Town, Tamar (P.).

P. nigrita Sond. — Derwent, Southport (R.) ; Tasmania (L. & P.).

P. patersonis Sond. — In *Zostera*, Low Head, 9/1950 (Cribb) ; Tasmania (Stuart).

P. spinuligera Zan. — George Town (Goodwin).

P. succulenta Harv. — George Town (Gunn) ; Tasmania (L. & P.) ; Low Head (P.).

LOPHOTHALIEAE

Brogniartella Bory

B. australis (Ag.) Schmitz — Tasmania (H.), (L. & P.) ; Tamar, Low Head, Middleton (P.).

B. feredayae (J. Ag.) Schmitz	George Town (Fereday) ; Currie River, Middleton (P.).
B. sarcocaulon (Harv.) Schmitz	North Coast (L.) ; Derwent (R.) ; Tasmania (L. & P.).

Doxodasya Schmitz

D. bulbochaete (Harv.) Falk.	George Town (H.) ; Low Head, Currie River (P.).

Lophothalia Kützing

L. verticillata (Harv.) Kütz.	George Town (H.) ; Tasmania (L. & P.) ; Tamar (P.).

BOSTRYCHIEAE

Bostrychia Montagne

B. harveyi Mont.	Tasmania (Stuart) ; Tasmania (L. & P.) ; Dover Creek, 9/1950 (Cribb).
B. mixta H. & H.	Port Arthur (H.) ; Port Arthur, 1/1951 (Cribb).
B. simpliciuscula Harv.	Port Arthur (H.).

CHONDRIEAE

Chrondria C. Ag.

C. debilis Harv.	Tamar (Gunn) ; George Town (L. & P.).
C. fusifolia H. & H.	Huon (R.) ; Derwent (L.) ; Tasmania (L. & P.) ; Low Head (P.).
C. harveyana J. Ag.	Channel (R.).
C. ovalifolia J. Ag.	Low Head (P.).
C. succulenta (J. Ag.) Falk.	Channel (R.).
C. tenuissima (God. & Wood) C. Ag.	George Town (L. & P.).

Cladurus Falkenberg

C. elatus (Sond.) Falk.	Tasmania (L. & P.) ; Currie River, Devonport (P.) ; Low Head, 1944 (H.D.G.).

Maschalostroma Schmitz

M. fastigiata Falk.	George Town (P.).

Coeloclonium J. Ag.

C. incrassatum J. Ag.	Tasmania (L.A.M.), (L. & P.).
C. opuntioides (Harv.) J. Ag.	George Town (Gunn).
C. verticillatum (Harv.) J. Ag.	Maria Is. (R.).

Dolichoscelis J. Ag.

D. clavifera J. Ag.	Tasmania (L.A.M.), (L. & P.).

LAURENCIEAE

Janczewskia Solms

J. tasmanica Falk. Tasmania (L. & P.).

Laurencia Lamouroux

L. botryoides (Turn.) Gaill. Derwent, Huon, Sandy Bay (R.); Tasmania (Gunn), (L. & P.); Low Head, Musselroe Bay (P.); Southport, 10/1951 (Cribb).

L. elata (Ag.) Harv. Passim (L.); Tasmania (L. & P.); Cape Grim, Eddystone Pt., Marrawah, Currie River (P.); Port Arthur, 3/1951 (Cribb).

L. filiformis (Ag.) Mont. No locality (L.); Tasmania (L. & P.); George Town (H.); Devonport (P.).

L. forsteri (Mert.) Grev. Blackman's Bay, Sandy Bay (R.); Tasmania (L. & P.); Low Head, Currie River, Eddystone Pt. (P.).

L. heteroclada Harv. King Is. (Spong).

L. obtusa (Huds.) Lamour. Passim (L.); Maria Is., Huon (R.).

L. tasmanica H. & H. Tamar, Eaglehawk Neck (L.); Retreat, Maria Is. (R.); Tasmania (L. & P.); Currie River, Low Head (P.); Low Head, 9/1950 (Cribb).

Corynecladia J. Ag.

C. umbellata J. Ag. Orford (L.A.M.).

PTEROSIPHONIEAE

Dictymenia Greville

D. harveyana Sond. Passim (L.); Tasmania (L. & P.); Low Head, George Town, Eddystone Pt., Middleton (P.); Bellerive, Shot Tower (R.); George Town (H.).

D. myriacantha Kütz. George Town (H.); Low Head, Currie River (P.).

D. tridens (Mert.) Grev. Tasmania (L. & P.); Musselroe Bay (P.).

Jeannerettia Hooker & Harvey

J. lobata H. & H. Passim (L.); Tasmania (L. & P.); Oyster Bay, Port Arthur, Tasmania (Lucas, 1915); Blackman's Bay, 5/1948 (H.N.B.); Low Head, George Town, Eddystone Pt., Cape Grim, Marrawah (P.).

J. pedicillata (Harv.) Pap. Passim (L.); Tasmania (L. & P.); Retreat (R.); Low Head, Tamar, Currie River, Eddystone Pt. (P.); Stewart's Bay, 6/1951, Orford, 6/1950 (Cribb).

POLYZONIEAE

Euzoniella Falkenberg

E. harveyana (Dene.) Falk.	Tasmania (Falkenberg).
E. incisa (J. Ag.) Falk.	North Coast (L.) ; Tasmania (H.), (L. & P.) ; Actaeon Is., Bellerive (R.) ; Low Head, 9/1950 (Cribb).

HERPOSIPHONIEAE

Herposiphonia Nageli

H. monilifera (H. & H.) Falk.	Tasmania (Gunn).
H. versicolor (H. & H.) Falk.	Passim (L.) ; Tasmania (L. & P.) ; Low Head, George Town, Currie River (P.) ; Port Arthur, 1/1952 (Cribb).

Herpopteros Falkenberg

H. fallax Falk.	No locality (L.) ; Tasmania (L. & P.) ;

AMANSIEAE

Lenormandia Sonder

L. marginata H. & H.	Passim (L.) ; George Town (Gunn) ; Channel (R.) ; Tasmania (L. & P.) ; South Arm, 8/1946 (P.B.) ; Low Head, Currie River, Eddystone Pt., Marrawah, Middleton, Gordon (P.) ; Taroona, 2/1951 (Cribb) ; Tasmania (Levring, 1946).
L. muelleri Sond.	Tasmania (L. & P.) ; Musselroe Bay, Swansea (P.).
L. prolifera (Ag.) J. Ag.	Tasmania (Gunn) ; Low Head (P.) ; Stewart's Bay, 6/1951 (Cribb).
L. smithiae (H. & H.) Falk.	No locality (L.) ; Eddystone Pt., Swansea (P.) ; 3 miles S.E. of Cape Barren Is., 11/1951 (Cribb).

Protokuetzingia Falkenberg

P. australasica (Mont.) Falk.	Tasmania (H.) ; Low Head (P.) ; Orford, 1/1952 (Cribb).

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The Cytology of Tasmanian Short-Horned Grasshoppers (Orthoptera: Acridoidea)

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WITH 1 PLATE AND 57 TEXT FIGURES

Summary

The cytology of twenty-six of the twenty-nine species of short-horned grasshoppers (superfamily *Acridoidea*) recorded from Tasmania is described. Intraspecific cytological polymorphism is described in some species. Cytological evidence of phylogenetic relationships has been indicated where possible.

Introduction

Mainly because of their large size, and general suitability for cytological study the chromosomes of the short-horned grasshoppers (superfamily *Acridoidea*) have been the subject of wide research. In the largest and most widely studied family, the Acrididae, early workers (McClung, 1905; Davis, 1908) reported the male number as being uniformly twenty-three rod-shaped chromosomes, but Granata (1910) showed that *Pamphagus* possessed nineteen rod-shaped chromosomes. With few exceptions an XO sex chromosome system is found. Later work has shown that one group of subfamilies of the Acrididae is characterised by the male diploid number of nineteen rod-shaped chromosomes, whilst another and larger group is characterised by the male diploid number of twenty-three. These are usually called the ten and twelve chromosome groups, and correspond to the Chasmosacci and Cryptosacci groups of subfamilies (Roberts, 1941). Cytologically the Chasmosacci is a very uniform group as has been shown by Rao (1937) and Powers (1942). The twelve chromosome group, however, has some cytological variability. In more than forty genera the characteristic male diploid chromosome number of twenty-three is found (White, 1945); but " centric fusions " (White, 1945) have been responsible for lowering the chromosome number of some species, although the characteristic twenty-three arms are still found. The most notable of these is the *Stenobothrus, Chorthippus, Stauroderus, Gomphocerus, Chloealtis, Chrysochraon* group where the number has been reduced to seventeen by three centric fusions (McClung, 1914; Robertson, 1916; Carlson, 1936; Darlington and Dark, 1932; Klingstedt, 1939). Recognition of this type of change was first due to the work of Robertson (1916). Reduction in chromosome number due to centric fusions reaches its maximum in *Philocleon anomalus* where the haploid number is six the X being fused to an autosome so that an XY sex mechanism is attained (Helwig, 1941). In some few species genuine reduction in chromosome arm

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number, apparently by translocation with centromere loss, has occurred (Helwig, 1942, and others). In at least three genera of grasshoppers (*Trimerotropis, Circotettix, Aerochoreutes*) belonging to the subfamily Oedipodinae another type of change occurs whereby acrocentric chromosomes are converted to metacentrics without reduction in chromosome number (Carothers, 1917, 1921, 1931; King, 1923; Helwig, 1929; White, 1945, 1949; 1951; Coleman, 1948). Coleman (1948) has shown that such changes are not due to pericentric inversions as White (1945) suggests. The centromere shifts may be due to three break re-arrangements, the centromere with a small portion of chromatin on each side of it being re-inserted in an interstitial position.

Intraspecific variations reported in grasshoppers include supernumerary chromosomes, which appear to be of two types. Those reported by Carroll (1920) vary in number from cell to cell whilst others (Carothers, 1917; White, 1949) are constant from cell to cell—at least within the testis. Most of these appear to be heterochromatic elements but very little satisfactory evidence concerning their mode of origin exists. Unequal bivalents other than those occurring in the *Trimerotropis* group of the Oedipodinae have been reported by several workers (Carothers, 1913, 1931; White, 1949; and others). Since the inequality is due to an extra heterochromatic region, and not to be a duplication or deficiency of the chromatin normally present, it is better, as White (1949) suggests, to refer to the extra region as a supernumerary chromosome region. Except for those possessing supernumerary chromosomes, which do not appear to ever become established as permanent members of the set, no member of the Acrididae is known where the haploid chromosome number is more than twelve. It may be as White (1945) suggests that there is some real barrier which prevents the chromosome number rising above twelve.

In spite of the uniform cytology within the Acrididae chromosome studies have made important contributions to the taxonomy of the group. Routine chromosome counts show fairly conclusively the affinities with one or other of the subfamily groups, even where aberrant form masks the more usual taxonomic characters, as in *Psednura pedestris* studied in this survey. The genera of the Acridinae (*Stenobothrus* group) which have three pairs of metacentric chromosomes probably represent a natural group (White, 1945). White (1949) has divided the genus *Trimerotropis* into two groups on cytological grounds, and it may well be that these groups are taxonomically valid. The results of Powers (1942) indicate that, where no re-arrangements such as centric fusions or centromere shifts, occur, relationships at or above the species level are hard to determine as the homologies are rather obscured, apparently by extensive chromatin rearrangements not involving centromeres.

Other families of the short-horned grasshoppers have received less attention from cytologists than the Acrididae, but several workers, notably Robertson (1916, 1930) and Harman (1915, 1920), have shown that the Tetrigidae have a uniform set of seven acrocentric chromosomes.

Materials and Methods

Testes of grasshoppers were fixed, usually in the field, in acetic-alcohol (1:3) or in San Felice's modification of Navashin's fixative. Material fixed in acetic-alcohol was bulk stained by the Feulgen technique,

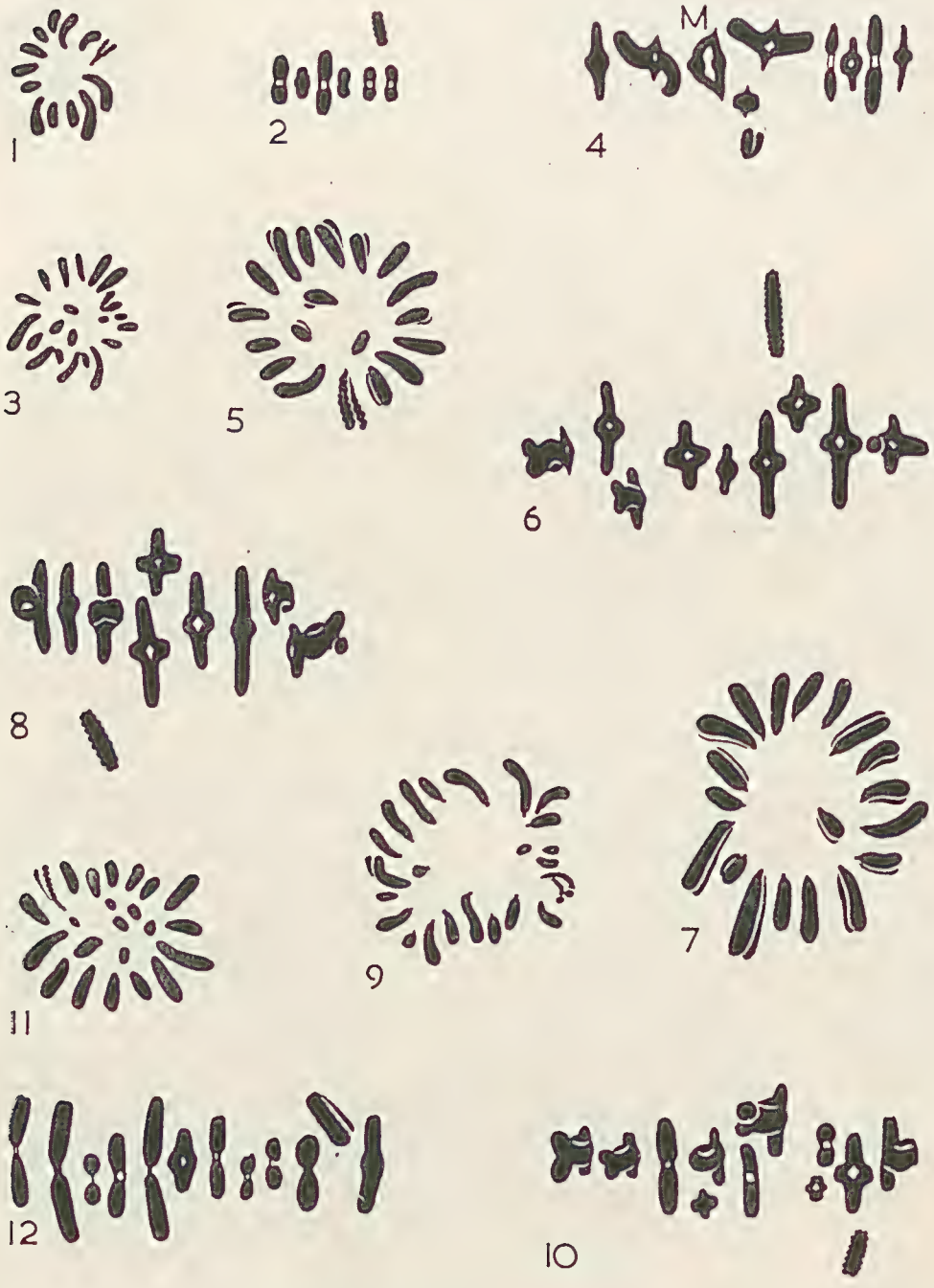
preparations being made according to the methods of Darlington and La Cour (1942). Before squashing on the slide the lower ends of the testis follicles, containing sperm only, were cut off. Acetic-alcohol was found to be the best fixative for all stages of mitosis and meiosis, and the Feuglen technique gave the quickest and most satisfactory staining. Material fixed in San Felice was microtomed at 20-24μ and stained in Newton's crystal violet.

Figures are reproduced at a magnification of X 1750.

TABLE I

CHROMOSOME NUMBERS OF TASMANIAN ACRIDOIDEA

Name of species and number of specimens studied	Collecting localities and altitudes	♂ chromosome number (2n)	Remarks
TETRIGIDAE			
Paratettix argillaceus (Erichs.) (4)	Nive R., Tarraleah Highway (800)	13 (fig. 1, 2)	Cytology typical of Tetrigidae
Tetrix sp. n.	Not collected.		
EUMASTACIDAE			
Moraba viatica (Erichs.) (5)	South Arm	19 (fig. 3, 4)	One pair of autosomes and X metacentric.
ACRIDIDAE (CHASMOSACCI)			
Monistria flavogranulata Sjöst (8)	Hobart, Ben Lomond (4200), Great Lake (3500), Bothwell (2500)	19 (fig. 5, 6)	
Psednura pedestris (Erichs.) (6)	Bridport, St. Helens	19 (fig. 7, 8)	Chromosome number & morphology typical of Chasmosacci group.
Psednura sp. n.	Not collected.		
ACRIDIDAE (CRYPTOSACCI)			
Kosciuscola sp. n. (5)	Great Lake (3500)	23 (fig. 9, 10)	
Phaulacridium vittatum (Sjöst.) (7)	Hobart, Ben Lomond (3400)	23 (fig. 11, 12)	
Phaulacridium nanum Sjöst. (6)	Avoca (600), Bothwell (1000), Bellerive, St. Helens	23 (fig. 13, 14)	
Urnisa rugosa Sauss. (3)	Bellerive	23 (fig. 15, 16)	
Exarna includens (Walk.) (3)	Hobart (500)	23 (fig. 17-21)	One individual heterozygous for supernumerary chromosome region.
Brachyexarna lobipennis Sjöst. (5)	Hobart, Melton-Mowbray (800)	23 (fig. 22, 23)	
Macrotona australis (Walk.) (1)	Hobart (300)	23 (fig. 24, 25)	
Peakesia brunnea (White) (2)	Coles Bay	23 (fig. 26, 27)	
Cirphula pyrrhocnemis (Stöl.) (3)	St. Helens, Bellerive	23 (fig. 28, 29)	
Goniaea australasiae (Leach) (3)	Hobart (200)	23 (fig. 30, 31)	
Tasmaniacris tasmaniensis (Bol.) (30)	Many localities	23 (fig. 32-34)	One individual trisomic in one cyst.
Russalpia albertisi (Bol.) (2)	Mt. Wellington (4200)	23 (fig. 35, 36)	
Austracris guttulosa (Walk.)	Not collected.		
Gastrimargus musicus (Fabr.) (4)	Hobart, Bridgewater	23 (fig. 37, 38)	
Oedaleus australis Sauss. (2)	Old Beach	23 (fig. 39, 40)	
Austroicetes frater (Brancs.) (2)	Lindisfarne (300)	23 (fig. 41, 42)	
Austroicetes pusilla (Walk.) (9)	Avoca (600), Lindisfarne	23 (fig. 43, 44)	One chromosome pair metacentric.
Austroicetes vulgaris (Sjöst.) (5)	Hobart, Mole Creek (800)	23 (fig. 45, 46)	Chiasmata frequently formed in short arms of chromosomes.
Chortoicetes terminifera (Walk.) (1)	Caragabal (N.S.W.)	23 (fig. 47, 48)	Recorded from Tasmania but cytology studied from N.S.W. specimen.
Cryptobothrus chrysophorus Rehn (6)	Hobart, Lindisfarne (300) Moorina (700)	23-27 (fig. 49-51)	Varying numbers of euchromatic supernumerary chromosomes.
Schizobothrus flavovittatus Sjöst. (2)	St. Helens	23 (fig. 52, 53)	
Genus & sp. n.1. (1)	Mt. Rufus (3500)	23 (fig. 54, 55)	
Genus & sp. n.2. (7)	Cradle Mt. (4000) Mt. Wellington (3700) Ben Lomond (4500)	23 (fig. 56, 57)	



For references to figures see opposite page

Observations

The names, with authorities, of all species of Acridoidea recorded from Tasmania are given in Table 1. Names are taken from the recent check list of Key (1952). Chromosome numbers, collecting localities and other information is given in this table. Most of the species show the chromosome number and morphology typical of the group to which they belong, and for these the information in the table, taken in conjunction with the figures is all that need be given. All Tasmanian species have XO sex mechanisms. The females have two X (sex) chromosomes and the males a single X chromosome. The unpaired X chromosome of the male is often recognisable at metaphase of spermatogonial mitosis by a characteristic undercondensation. During meiosis it is always recognisable as an unpaired chromosome which lies off the equatorial plate at first metaphase and segregates to one pole in advance of the autosomes. With only two exceptions the species studied have all their chromosomes acrocentric. Acrocentric chromosomes appear, superficially, to possess a completely terminal centromere but this is not the case as a small terminal portion of chromatin or short-arm exists beyond the centromere. The short-arm is often recognisable at mitosis as a terminal knob. In other species chiasmata in this region clearly demonstrate the existence of the short-arms, the bivalents having a characteristic appearance.

The following observations deal only with those species which call for further comment.

Family EUMASTACIDAE

Moraba viatica

Moraba viatica, the only Tasmanian Eumastacid, was collected during this survey for the first time since the original record of 1842. The male has nineteen chromosomes (figs. 3, 4). Eight pairs are rod-shaped (acrocentric) and one pair of autosomes and the X chromosome are V-shaped (metacentric).

The only published information concerning the cytology of the Eumastacidae is given by Rehn (1948), who lists chromosome numbers (determined by E. R. Helwig) of six American species distributed amongst five subfamilies. In these species the male diploid numbers vary from seventeen to twenty-three. In all cases the X chromosome is metacentric and all the autosomes acrocentric (personal communication from Dr. E. R. Helwig). In four species of Australian Eumastacidae studied by the

Explanation of Figs. 1-12

Figure 1: *Paratettix argillaceus*, metaphase of spermatogonial mitosis.
Figure 2: *Paratettix argillaceus*, first metaphase.
Figure 3: *Moraba viatica*, spermatogonial metaphase. X chromosome and one autosomal pair metacentric.
Figure 4: *Moraba viatica*, first metaphase. M—metacentric bivalent.
Figure 5: *Monistria flavogranulata*, spermatogonial metaphase. X chromosome undercondensed.
Figure 6: *Monistria flavogranulata*, first metaphase.
Figure 7: *Psednura pedestris*, spermatogonial metaphase.
Figure 8: *Psednura pedestris*, first metaphase.
Figure 9: *Kosciuscola* sp. n., spermatogonial metaphase.
Figure 10: *Kosciuscola*, sp. n., first metaphase.
Figure 11: *Phaulacridium vittatum*, spermatogonial metaphase.
Figure 12: *Phaulacridium vittatum*, first metaphase.

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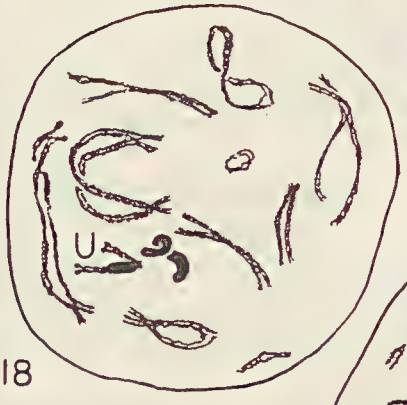

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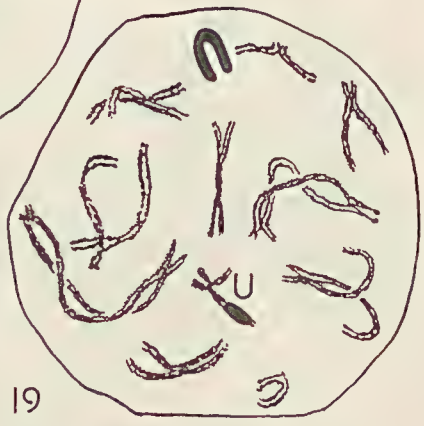

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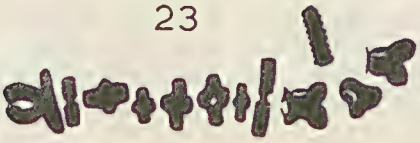

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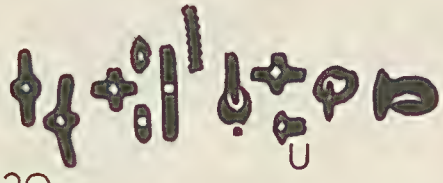

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For references to figures see opposite page

author the numbers range between fifteen and twenty-one, and in all four species at least one pair of autosomes are metacentric. The cytological differences may thus reflect the taxonomic differences between the Australian and American forms Rehn (1948) having placed the Australian Eumastacidae in a distinct new subfamily.

In *Moraba viatica* and other Australian species of Eumastacidae the chromosomes range in length from less than one micron to about five microns. This is approximately the same size as the chromosomes of the primitive family Tetrigidae. In the Acrididae studied the length varies from one micron to greater than eight microns. The size and general arrangement of the testis follicles in the Eumastacidae also resembles that of the Tetrigidae. The cytology of *Moraba* and other Australian Eumastacidae will be the subject of a later paper.

Family ACRIDIDAE

CHASMOSACCI GROUP OF SUBFAMILIES

The relationships of the Chasmosacci group with the larger Cryptosacci group are uncertain. Students of the Acrididae are not in agreement as to which group is the more primitive. Roberts (1941) considers, on the basis of their phallic structures, that the Chasmosacci are ancestral. Uvarov (1943) however, considers the Chasmosacci to have been derived from one subfamily of the Cryptosacci group. The very uniform cytology of the Chasmosacci suggests that they may be a group derived from Cryptosacci stock, two chromosomes being lost in the process. Such a change is known to have taken place independently in several of the Cryptosacci.

Monistria flavogranulata

This species has the diploid chromosome number characteristic of the Chasmosacci group. Eighteen rod-shaped autosomes and one rod-shaped X chromosome are found in the male (figs. 5, 6, 58, 59).

Psednura pedestris

Psednura has hitherto been assigned to the Cryptosacci group of subfamilies. Its chromosome complement of nineteen acrocentrics (figs. 7, 8, 60, 61) shows, however, that it belongs with the ten chromosome

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EXPLANATION OF FIGS. 13-23

Figure 13: *Phaulacridium nanum*, spermatogonial metaphase.
Figure 14: *Phaulacridium nanum*, first metaphase.
Figure 15: *Urnisa rugosa*, spermatogonial metaphase.
Figure 16: *Urnisa rugosa*, first metaphase.
Figures 17-21: *Exarna includens*.
Figure 17: Spermatogonial metaphase in individual with supernumerary chromosome region. Only five small chromosomes present.
Figure 18: Diplotene. The supernumerary region and the X chromosome are over-condensed. Chiasma in distal portion of unequal bivalent (U).
Figure 19: Diplotene. Chiasma in proximal portion of unequal bivalent.
Figure 20: First metaphase. Chiasma in proximal portion of unequal bivalent (U).
Figure 21: First metaphase from an individual without a supernumerary chromosome region.
Figure 22: *Brachyexarna lobipennis*, spermatogonial metaphase.
Figure 23: *Brachyexarna lobipennis*, first metaphase.

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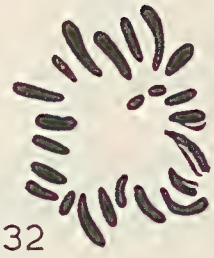
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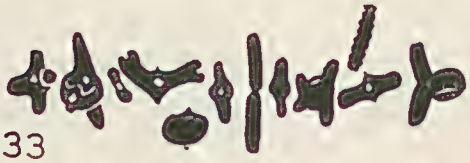
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For references to figures see opposite page

group. Also the testis of this species is of the " radiating " type (Laird. 1943), which is found in the subfamilies usually placed in the Chasmosacci group. Dr. K. H. L. Key (personal communication) has noted other characters which agree with the above placing of *Psednura*.

CRYPTOSACCI GROUP OF SUBFAMILIES

Exarna includens

One specimen of the three studied shows an unequal chromosome pair. At spermatogonial metaphase in this individual only five small chromosomes are observed (fig. 17). In individuals without the unequal pair six small chromosomes occur at spermatogonial mitosis. In the individual with the unequal pair one of the smallest chromosomes has an intercalary supernumerary chromosome region inserted near its distal end. Like the supernumerary chromosome region observed by White (1949) in *Trimerotropis bilobata* this is heterochromatic being markedly overcondensed in the prophase stages of meiosis (figs. 18, 19). There is never more than one chiasma formed in the bivalent, but it may occur in either of two positions. If the chiasma occurs in the distal part beyond the supernumerary region (fig. 18) the unequal bivalent orientates on the metaphase plate so that the smaller chromosome is directed toward one pole and the larger chromosome toward the opposite pole (fig. 62). The large and small members of the pair then separate at first division (pre-reduction in the terminology of earlier workers). If, on the other hand the single chiasma occurs in the proximal portion of the chromosome (figs. 19, 20) the supernumerary region separates at the first meiotic division (post-reduction). A rough count indicates that the two types of bivalent occur with approximately equal frequency.

Failure of chiasma formation between the members of the unequal pair is observed in some cells (fig. 63) indicating that the supernumerary region may, perhaps, suppress crossing over in some cases.

Tasmaniacris tasmaniensis

Thirty individuals of this common species were studied. Apart from occasional tetraploid cells only one individual shows any cytological abnormality. In one cyst of cells in this specimen an extra euchromatic element is present which does not occur elsewhere in the testis. The extra element appears to be a duplication of one autosome caused by non-disjunction at a preceding spermatogonial division. It is thus homologous with

Explanation of Figs. 24-34

Figure 24: *Macrotona australis*, spermatogonial metaphase.
Figure 25: *Macrotona australis*, first metaphase.
Figure 26: *Peakesia brunnea*, spermatogonial metaphase.
Figure 27: *Peakesia brunnea*, first metaphase.
Figure 28: *Cirphula pyrrhocnemis*, spermatogonial metaphase.
Figure 29: *Cirphula pyrrhocnemis*, first metaphase.
Figure 30: *Goniaea australasiae*, spermatogonial metaphase.
Figure 31: *Goniaea australasiae*, first metaphase.
Figures 32-34: *Tasmaniacris tasmaniensis*.
Figure 32: Spermatogonial metaphase.
Figure 33: First metaphase.
Figure 34: Late first anaphase in trisomic cyst. The supernumerary element has divided into chromatids (shown in black) which are undergoing belated anaphase movement.

one autosomal pair but a trivalent is not formed at meiosis since the chiasma frequency of the bivalent is never greater than unity.

During meiosis the extra element orientates on the metaphase plate at the end of the first metaphase and divides into chromatids at late first anaphase (fig. 34). In none of the cells studied did the supernumerary chromosome pass to one pole without division or fail to complete division. In a trisomic grasshopper studied by Callan (1941) the supernumerary became included in one of the first division daughter cells without dividing in 50 per cent of the cells studied. In all other cases it reached the plate but failed to divide completely into chromatids and a diploid restitution nucleus was formed.

Austroicetes pusilla

Austroicetes pusilla differs from all other Tasmanian Acrididae in possessing one pair of metacentric chromosomes (M, fig. 44). When such metacentrics arise by centric fusion the haploid chromosome number is automatically reduced by one (White, 1945). Since the chromosome number of the species is that characteristic of the rest of the group it is possible that the change is of the type which occurs in the *Trimerotropis* group of Acrididae extensively studied by White (1949, 1951) and others. These changes are known as centric shifts, the precise mechanism for the change being unknown. In all species studied by White in which any centric shifts have occurred in the autosomes the X chromosome is metacentric. In *Austroicetes pusilla* this is not the case as the X is acrocentric, and the change can, perhaps, be more closely compared with that occurring in a South African grasshopper *Oedaleus nigrofasciatus* studied by Nolte (1939). In this species four pairs of autosomes are metacentric and the X chromosome is acrocentric. All the specimens of *Austroicetes pusilla* studied had the same pair of homologous chromosomes metacentric (figs. 43, 44, 72). Because of the small size of the sample studied (nine specimens), it is impossible to say whether the change is fully established in the species or not. Further analysis of populations may show that cytological polymorphism such as is found in the *Trimerotropis* group occurs in this grasshopper.

Austroicetes vulgaris

At first metaphase of meiosis (fig. 46) unusual bivalent configurations occur in this species. These are due to the localisation of chiasmata in the short arms of some of the chromosomes. Earlier workers (Darlington,

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EXPLANATION OF FIGS. 35-46

Figure 35: *Russalpia albertisi*, spermatogonial metaphase.
Figure 36: *Russalpia albertisi*, first metaphase.
Figure 37: *Gastrimargus musicus*, spermatogonial metaphase.
Figure 38: *Gastrimargus musicus*, first metaphase.
Figure 39: *Oedaleus australis*, spermatogonial metaphase.
Figure 40: *Oedaleus australis*, first metaphase.
Figure 41: *Austroicetes frater*, spermatogonial metaphase.
Figure 42: *Austroicetes frater*, first metaphase.
Figure 43: *Austroicetes pusilla*, spermatogonial metaphase. One autosomal pair metacentric.
Figure 44: *Austroicetes pusilla*, first metaphase. M—metacentric bivalent.
Figure 45: *Austroicetes vulgaris*, spermatogonial metaphase.
Figure 46: *Austroicetes vulgaris*, first metaphase. The two bivalents at left each have a chiasma in their short arms.

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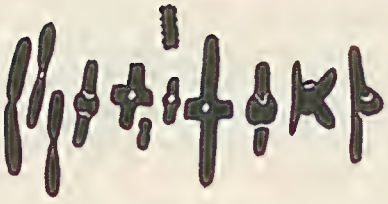
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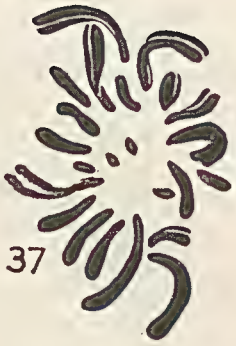
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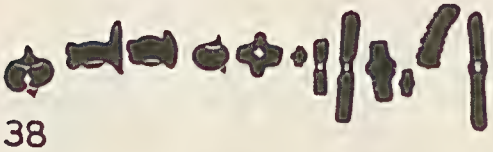
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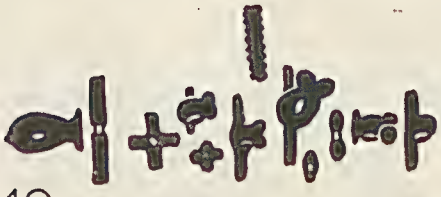
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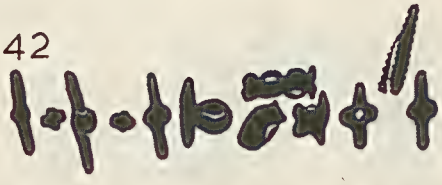
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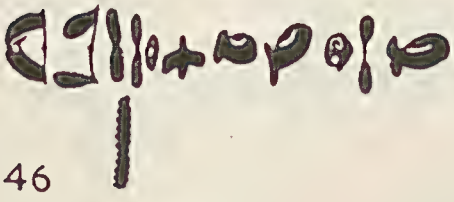
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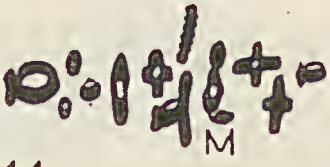
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1936, and others) have shown that the rod-shaped chromosomes of the Acrididae possess short arms in which crossing-over can occur. In nearly all the cells studied in *Austroicetes vulgaris* at least one bivalent shows a single chiasma in the short arm and none in the long arm. It is impossible to identify any one chromosome with certainty from cell to cell but it is probable that one of the larger chromosomes always undergoes chiasma formation in its short arm and only rarely in its long arm.

Cryptobothrus chrysophorus

Cryptobothrus chrysophorus is a typical member of the Cryptosacci group with twenty-three chromosomes. It, however, shows two abnormalities of some cytological interest. They are (1) most individuals possess supernumerary chromosomes; and (2) part of one individual studied is heterozygous for a reciprocal translocation.

Supernumerary chromosomes of grasshoppers previously studied seem to be of two general types. Carroll (1920) reports one, two or three extra elements present in different cells of the same animal. Single supernumeraries show precocious behaviour at prophase and nearly always segregate to one pole like the X. When two are present they pair to form a normal bivalent which does not show precocious behaviour at prophase and divides at anaphase like a normal euchromatic pair. Supernumeraries studied by White (1949, 1951) in wild populations of *Trimerotropis* and *Circotettix* behave somewhat differently. They are overcondensed at prophase and are constant from cell to cell. White has reported individuals with one, two or three extra elements. In White's material the supernumeraries nearly always pass to one first division pole undivided. When more than one is present bivalents or trivalents are sometimes formed but the elements often pass to one pole without prior pairing. A single supernumerary observed by the author in the grasshopper *Austracris proxima* shows the same behaviour as White has reported, the extra element passing to one pole without dividing at first division.

In *Cryptobothrus chrysophorus* the extra elements show no precocious behaviour at prophase. Their cycle of condensation and general behaviour is completely autosomal. This would indicate that they are euchromatic and not genetically inert as heterochromatic supernumeraries probably are (White, 1949, 1951). The origin of the extra elements in *Cryptobothrus* may possibly be due to reduplication of one of the smallest autosomes as a single supernumerary is the same size as members of the smallest chromosomal pair and behaves as autosomal univalents do at meiosis. The single extra element moves onto the plate at late metaphase (fig. 51) and usually

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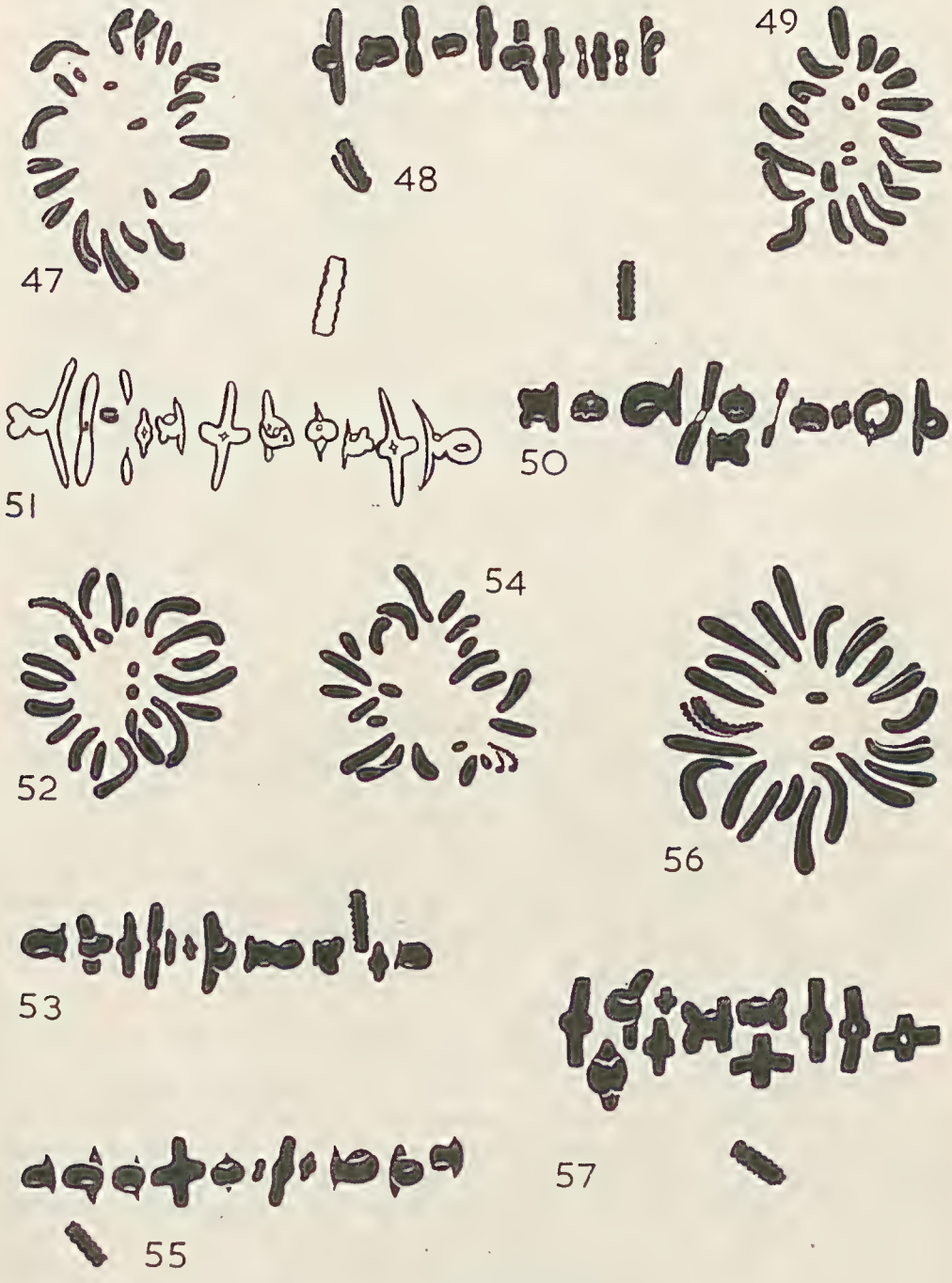
EXPLANATION OF FIGS. 47-57

Figure 47: *Chortoicetes terminifera*, spermatogonial metaphase.
Figure 48: *Chortoicetes terminifera*, first metaphase.
Figures 49-51: *Cryptobothrus chrysophorus*.
Figures 49, 50: Spermatogonial metaphase and first metaphase in an idividual with no supernumerary chromosomes.
Figure 51: Late first metaphase in cell with single supernumerary (shown in black).
Figure 52: *Schizobothrus flavovittatus*, spermatogonial metaphase.
Figure 53: *Schizobothrus flavovittatus*, first metaphase.
Figure 54: Genus and sp.n.1., spermatogonial metaphase.
Figure 55: Genus and sp. n.1., first metaphase.
Figure 56: Genus and sp. n.2., spermatogonial metaphase.
Figure 57: Genus and sp. n.2., first metaphase.



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divides into chromatids at late anaphase (fig. 70). One daughter chromatid is incorporated in each first division nucleus and these do not divide at second division. Sometimes the division of the univalent is incomplete at first division and it becomes incorporated in only one daughter nucleus. In these cases the supernumerary divides at second division. When two or four supernumeraries are present they regularly form one or two bivalents which are identical in size and behaviour with the smallest autosomal bivalent (figs. 67, 68). When three are present a bivalent and univalent are formed. Multivalent formation is not expected since the smallest bivalents never have more than one chiasma. The number of supernumerary chromosomes is not constant in all cells of the testis of one animal. This is due to the mitotic behaviour of the supernumeraries which is abnormal. At metaphase of spermatogonial mitosis they often lie off the equatorial plate, either above or to one side of it, and at anaphase are incorporated in one daughter nucleus without division (fig. 71).

In one cyst of cells in an individual of *Cryptobothrus* a quadrivalent is regularly formed (fig. 69). All other cells of this individual have eleven bivalents plus one or more supernumeraries, but in this cyst nine bivalents and a quadrivalent regularly occur in at least twenty cells. The quadrivalent is presumably due to a reciprocal translocation between two non-homologous autosomes during the spermatogonial divisions prior to meiosis. In some individuals supernumerary chromosome regions also occur (figs. 67, 68).

The cytology of *Cryptobothrus chrysophorus* will be treated in detail in a later paper.

Genus and sp. n.2.

This species is divided into several phenotypically distinct subspecies. It is worthy of note that no cytological differences between subspecies can be observed. The chromosomes of Genus and sp. n.2. do not closely resemble those of any other Tasmanian species except possibly *Tasmaniacris tasmaniensis*. In the majority of the twelve-chromosome group of Acrididae two or three pairs of autosomes are markedly smaller than the remainder, but in Genus and sp. n.2. only one pair differ significantly in size. (figs. 56, 57, 65, 66).

Summary

The cytology of twenty-six species of Tasmanian short-horned grasshoppers is described. All have XO sex-determination mechanisms.

Moraba viatica (2n=19), and other Australian species of the family Eumastacidae are separated by clear chromosomal differences from the remaining Acridoidea. In size their chromosomes more closely resemble those of the family Tetrigidae than those of the Acrididae.

Psednura pedestris has the chromosome number and morphology and also the testis structure typical of the Chasmosacci group of subfamilies. On cytological evidence the Chasmosacci (ten chromosome) group appears to have been derived from the Cryptosacci (twelve chromosome) group.

Of three specimens of *Exarna includens* one shows heterozygosity for a precociously condensed supernumerary chromosome region.

One of the thirty individuals of *Tasmaniacris tasmaniensis* studied shows cytological abnormality. In this individual one cyst of cells has an extra chromosome which is probably a duplication of one member of a homologous pair of autosomes.

Two of the three species of *Austroicetes* studied show differences which mark them clearly from each other and from the rest of the Tasmanian representatives of their family. *Austroicetes pusilla* has one pair of metacentric chromosomes, whereas the remaining Acrididae have all their chromosomes acrocentric. In *Austroicetes vulgaris* localisation of chiasmata in the short arms of acrocentric chromosomes is frequent, whereas in all other species it is rare or non-existent.

In most individuals of *Cryptobothrus chrysophorus* supernumerary chromosomes are present. These vary in number from cell to cell within the testis of the same individual. The behaviour of the extra elements at meiosis is completely autosomal. One group of cells in one individual of *Cryptobothrus* shows regular quadrivalent formation whereas no quadrivalent is formed in any of the remaining cells. The quadrivalent is due to the individual being heterozygous for a reciprocal translocation in one cyst of cells.

Genus and sp. n.2. is shown to differ markedly in its chromosome morphology from all other species except *Tasmaniacris tasmaniensis*.

Acknowledgments

I wish to thank Dr. K. H. L. Key, of C.S.I.R.O., Division of Entomology, who provided an excellent key for the identification of Tasmanian Acrididae and who has given invaluable help in checking identifications and in collecting material in New South Wales. I also wish to thank Mr. B. A. B. Edwards, who assisted in collecting many of the specimens, and Professor H. N. Barber for guidance during the investigation, which was begun whilst in receipt of a Commonwealth Research Grant.

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EXPLANATION OF PLATE

(Figs. 58-72)

Microphotos of Feulgen squashes reproduced at a uniform magnification of X1600.

Figure 58: *Monistria flavogranulata*, spermatogonial metaphase.

Figure 59: *Monistria flavogranulata*, first metaphase.

Figure 60: *Psednura pedestris*, spermatogonial metaphase.

Figure 61: *Psednura pedestris*, first metaphase.

Figure 62: *Exarna includens*, first metaphase. The unequal bivalent (near centre) has a terminal chiasma.

Figure 63: *Exarna includens*, first metaphase. The unequal sized chromosomes are unpaired.

Figure 64: *Goniaea australasiae*, diplotene. Two bivalents are precocious and one is slightly precocious.

Figure 65: Genus and sp. n.2., late prophase of spermatogonial mitosis. One of the smallest pair of autosomes lies beneath a large chromosome and is almost obscured. The size distribution of the chromosomes shows only one pair to be markedly smaller than the remainder.

Figure 66: Genus and sp. n.2., first metaphase.

Figure 67: *Cryptobothrus chrysophorus*, first metaphase. Two supernumerary chromosomes are present forming an extra small bivalent.

Figure 68: *Cryptobothrus chrysophorus*, first metaphase. Four supernumerary chromosomes forming two extra small bivalents. One bivalent (third from right) has a supernumerary chromosome region. Figs. 67 and 68 are from the same individual.

Figure 69: *Cryptobothrus chrysophorus*, diakinesis. A cell from the cyst in which reciprocal translocation has occurred. Nine bivalents, one quadrivalent, the unpaired X chromosome and a single supernumerary are present.

Figure 70: *Cryptobothrus chrysophorus*, first anaphase. The single supernumerary divided into chromatids which are still near the equatorial plate (at right).

Figure 71: *Cryptobothrus chrysophorus*, spermatogonial mitosis. The right hand cell has seven small chromosomes. Three are supernumeraries and one of these is left off the spindle (upper left). In the cell seen in side view one supernumerary lies off the plate. Figs. 69 and 70 are from the same individual.

Figure 72: *Austroicetes pusilla*, first metaphase. Left hand bivalent beginning to separate. Metacentric bivalent second from left.

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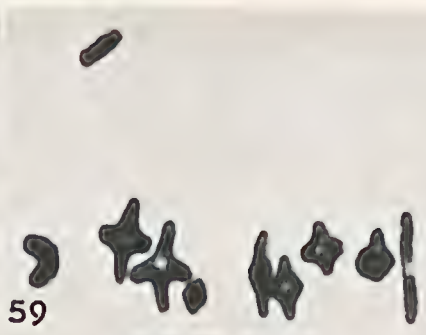
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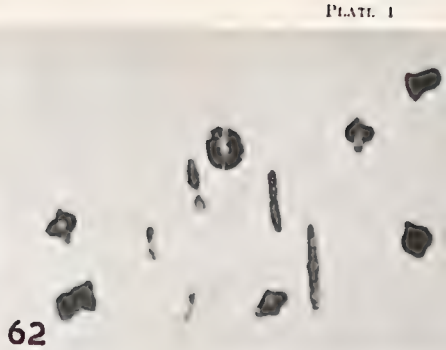
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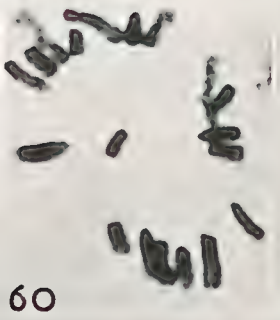
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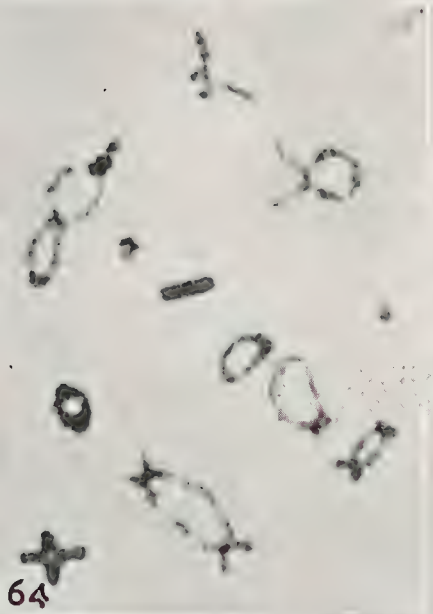
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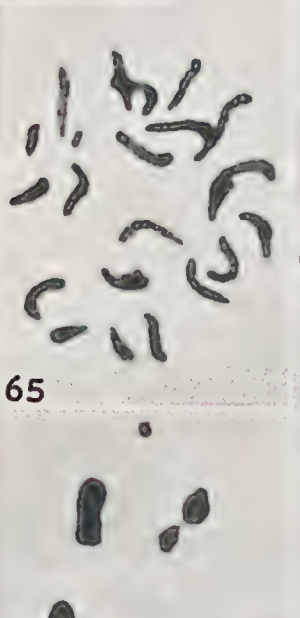
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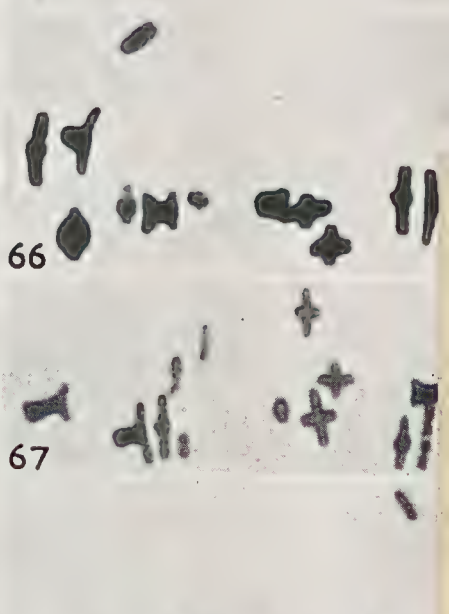
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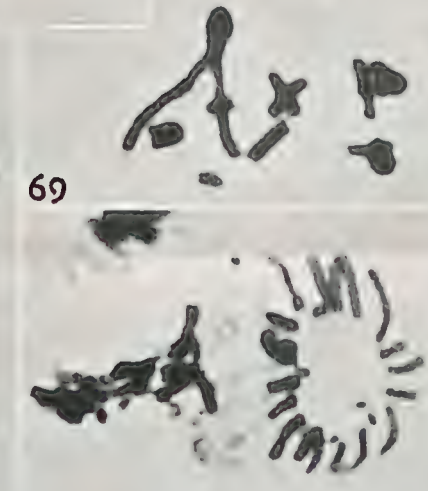
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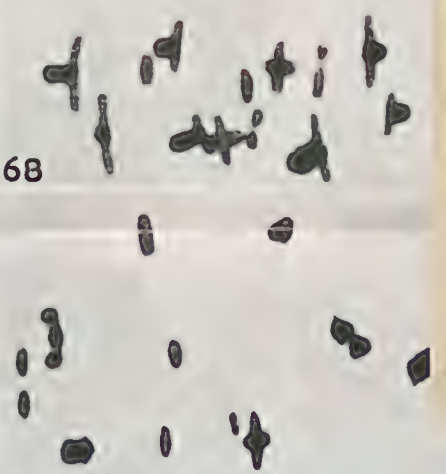
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The Occurrence of Pillow Lavas near Penguin, Tasmania

By

Beryl Scott

WITH 1 PLATE AND 1 MAP

Abstract

Spilitic pillow lavas associated with laminated shales and tillite occur near Penguin, North-West Coast, Tasmania. These are correlated with similar rocks at Smithton and on King Island, which are considered to belong to the Dundas Group and thus to be Cambrian in age.

Nye in 1931 reported the occurrence of dolerite of Lower Palaeozoic age at Groom's Slip, just east of Penguin along the north-west coast of Tasmania. The reference to this report which appears in the Geological Index of Tasmania was brought to the notice of the author by Miss E. M. Smith, Geological Indexer for Tasmania, of the Bureau of Mineral Resources. It was decided to investigate the occurrence, especially as it appeared likely that it might be similar to the so-called dolerite of Smithton which has recently been re-interpreted by Carey and Scott (1952) as a suite of volcanic rocks similar to those outcropping along the south-east coast of King Island and elsewhere on the west coast of Tasmania.

The dolerite at Groom's Slip has also proved to belong to a volcanic suite which, as elsewhere in Tasmania, is associated with tillite and laminated shales. The association of pillow lavas, tillite and laminated shales is so characteristic that taken with their structural and field relations the author has no hesitation in correlating them with the Dundas Group of Cambrian age.

Commencing a little east of Watcombe Beach, Penguin, the tillite and volcanic rocks outcrop as far east as Lonah Point, a distance of about two miles. The width of outcrop is no doubt due to a series of small anticlines and synclines and minor faulting but it also seems that the volcanic rocks are of a considerable thickness. The greatest development is at Groom's Slip.

Evidence that the rock is extrusive and not intrusive is revealed by the occurrence of well developed pillow structure. The pillows range in diameter from one to six feet and are stacked one on top of the other, the overlying pillows often being bulged over those underneath as illustrated by Figure 1. Mostly they are ellipsoidal in shape but some have a tendency to an elongated twisted form as has been described by the author from King Island (Scott 1951). Some of the pillows bear the characteristic cavity in the centre. (See Figure 2).

Associated with the pillow lavas are normal massive lavas, which as at King Island and Smithton seem to overlie the shales and tillite but underlie the pillow lava, volcanic breccia and tuff. Vulcanicity must have begun before the deposition of the tillite and shales was complete because minor flows of lava are interbedded with the sediments.

In the hand specimen the pillow lava is the usual fine grained greyish green rock already described from the other areas. Microscopically, it consists of tiny laths of albite with intergranular augite and grains of ilmenite scattered throughout the rock. Occurring in the spaces between the plagioclase laths and augite granules are patches of pale green chlorite containing granules of secondary sphene. The albite has a composition Ab_{98} An_2 and in some parts of the rock is partly sericitized and chloritized. The augite is quite fresh and often has simple twinning.

Petrographically the rock is very similar to a basaltic type from King Island the analysis of which is similar to those of the pillow lavas from King Island and Smithton. These analyses have been listed for comparison with that of the Groom's Slip lava.

	I	II	III	IV	V
SiO_2	48·35	50·01	52·61	50·16	53·20
Al_2O_3	16·82	15·38	13·03	18·01	19·15
Fe_2O_3	2·85	4·86	3·90	13·98	7·72
FeO	10·21	9·21	8·48	4·15	3·87
MgO	4·46	5·85	5·10	1·84	2·89
CaO	9·55	6·35	7·26	1·40	1·24
Na_2O	3·78	4·77	5·60	4·43	5·17
K_2O	0·42	0·40	0·42	0·83	0·58
H_2O+	2·32	2·60	1·65		
$H_2O—$	0·32	0·23	0·10	2·10	4·00
CO_2	n.dt.	0·13	0·05		
TiO_2	0·78	0·73	0·72	2·00	1·74
MnO	0·10	0·21	0·19	Tr.	Tr.
P_2O_5	n.dt.	0·09	Tr.	0·25	0·30
S	—	—	0·08	Tr.	0·05
Total	99·96	100·82	99·19	99·15	99·91

I. Spilite, Groom's Slip, Penguin, Tas. Anal. B. Scott.
II. Spilite (Basaltic type), King Island, Tas. Anal. B. Scott.
III. Spilite (Pillow lava), King Island, Tas. Anal. B. Scott.
IV. Mugearite (Pillow lava), Smithton, Tas. (Bulletin 41, p. 69).
V. Mugearite (Pillow lava), Smithton, Tas. (Bulletin 41, p. 69).

(Note: The variation in the CaO, MgO, Fe_2O_3 content of the Smithton rocks is probably due to the replacement of the ferromagnesian mineral by iron ores, particularly haematite.)

It seems that the Groom's Slip lava has a chemical composition comparable with those at King Island and Smithton and as such would fall into the category of a spilite.

Locality Index

Locality	Quadrangle	Latitude	Longitude
Groom's Slip	Devonport 29	41° 7′	146° 6′
King Island	—	39° 35′ — 40° 16′	143° 50′ — 145° 17′
Lonah Point	Devonport 29	41° 7′	146° 7′
Penguin	Devonport 29	41° 7′	146° 4′
Smithton	Smithton 21	40° 41′	145° 6′
Watcombe Beach	Devonport 29	41° 8′	146° 5′

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Locality Map of North-West Coast of Tasmania

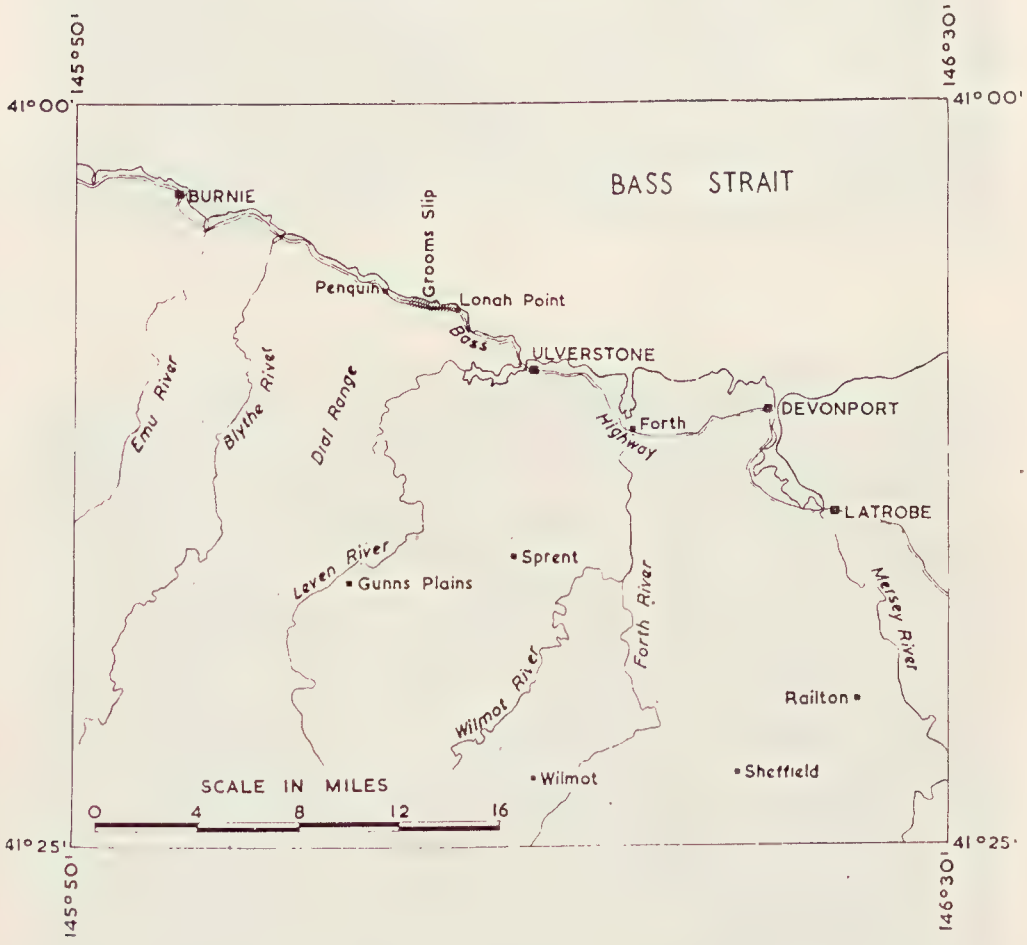

FIG. 1.—General view of pillows of lava illustrating the bulging effect of the pillows over each other.

FIG. 2.—Pillows of lava, one (near hammer) of which shows a central cavity.

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A Provisional Check-List of the Acridoidea of Tasmania (Orthoptera)

By

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Acridoidea, or the " short-horned " grasshoppers, were being collected sporadically in Tasmania as early as the first half of the last century, when specimens taken by Schayer at Woolnorth, in the north-western corner of the island, formed the basis for descriptions of five species by Erichson (1842). Sjöstedt (1935) lists 16 nominal species from Tasmania, but four of these should be rejected on various grounds: *Tasmaniacris micropteryx* Sjöst. and *Cedarinia angustipennis* Sjöst. are propably both synonyms of *Tasmaniacris tasmaniensis* (Bol.) ; *Monistria conspersa* Stål is probably a mistaken identification of *M. flavogranulata* Sjöst.; while *Phaulacridium manca* (Bol.) is probably identical with *P. vittatum* (Sjöst.) which Sjöstedt records under the name *Phaulacridium gemini* (Sjöst.) Sjöstedt does not list two species of Erichson's whose types he was unable to locate. These are " *Acridium ambulans* " and " *Calliptamus baiulus* "; neither has been identified in any collection from Tasmania since Schayer. " *Acridium ambulans* ", however, is probably identical with *Phaulacridium vittatum*. If this can be established by inspection of the type material, *ambulans* will have priority over all other trivial names for that species. For the present the name *vittatum* is retained, notwithstanding that it is threatened, not only by *ambulans*, but also by *manca*. The description of *Calliptamus baiulus* can scarcely refer to any member of the Acridoidea known to the author from Tasmania. It may well be a species still awaiting rediscovery.

If the above adjustments are made to Sjöstedt's list, and Erichson's two doubtful species are omitted, we are left with authentic published records of 12 species of Acridoidea from Tasmania. This number has not been added to since Sjöstedt's 1935 monograph.

The first extensive and systematic collecting of Acridoidea to be undertaken in Tasmania was carried out by an expedition from the Division of Entomology, Commonwealth Scientific and Industrial Research Organization, in January and early February, 1948. This expedition, which was led by the author, covered some 2800 miles and collected in every major

TABLE 1

Annotated List of the Species of Acridoidea known to occur in Tasmania

Species	Known from museum material collected prior to 1948	Recorded in literature	Type material from Tasmania	Distribution restricted to Tasmania	Collected by Key et al., 1948	Collected by Riek, 1948	Collected by Calaby, 1949	Collected by Sharman et al., 1950-51
Tetrigidae								
Tetrix sp. n.	+				+			+
Paratettix argillaceus (Erichs.) 1842	+	+	+		+			+
Eumastacidae								
Moraba viatica (Erichs.) 1842	+	+	+	?[1]				+
Acrididae								
Monistria flavogranulata Sjöst. 1921	+	+	+	+	+	+	+	+
Psednura pedestris (Erichs.) 1842	+	+	+		+			+
Psednura sp. n.				+	+			
Kosciuskola sp. n.	+			?[1]	+			+
Phaulacridium vittatum (Sjöst.) 1920	+	+			+	+	+	+
Phaulacridium nanum Sjöst. 1921	+				+		+	+
Urnisa rugosa Sauss. 1884								+
Exarna includens (Walk.) 1870	+				+	+	+	+
Brachyexarna lobipennis Sjöst. 1921					+	+	+	+
Macrotona australis (Walk.) 1870	+				+	+	+	+
Peakesia brunnea (White) 1841						+		+
Cirphula pyrrhocnemis (Stal) 1861	+				+	+		+
Goniaea australasiae (Leach) 1814	+	+			+		+	+
Tasmaniacris tasmaniensis (Bol.) 1898	+	+	+	+	+	+	+	+
Russalpia albertisi (Bol.) 1898	+	+	+	+	+		+	+
[2]*Austracris guttulosa* (Walk.) 1870								+
Gastrimargus musicus (Fabr.) 1775	+	+			+		+	+
Oedaleus australis Sauss. 1888	+	+			+		+	+
Austroicetes frater (Brancs.) 1897	+				+	+	+	+
Austroicetes pusilla (Walk.) 1870					+		+	+
Austroicetes vulgaris (Sjöst.) 1931	+	+			+	+	+	+
[3]Chortoicetes terminifera (Walk.) 1870	+				+			+
Cryptobothrus chrysophorus Rehn 1907					+	+	+	+
Schizobothrus flavovittatus Sjöst. 1921	+	+			+			+
Genus & sp. n. 1.	+			+	+		+	+
Genus & sp. n. 2.	+			+	+		+	+
Totals 29	22	12	6	6, two others doubtful	25	11	17	27

1 Represented on the mainland by a closely similar form from which it may or may not be specifically distinct.
2 Reported only from King Island (personal communication from Dr. J. W. Evans), and possibly not established there.
3 A periodical invader from the mainland; not established in Tasmania.

Names in bold-face are firmly established as a result of revisionary work now in press.

climatic, edaphic, and vegetational zone on the main island. During the same period Mr. E. F. Riek, also of the Division of Entomology, collected grasshoppers, along with other insects, in a few areas. In January and February, 1949, a second C.S.I.R.O. expedition visited Tasmania, and grasshoppers were collected by Mr. J. H. Calaby. As a result of these surveys a number of additional species were recorded, several of them undescribed. At the request of Professor H. N. Barber, of the University of Tasmania, a key to all the species of the family Acrididae then known to occur in Tasmania (which include all but three of the Acridoidea) was prepared by the author and circulated privately to interested persons in that State. Working with this key, Mr. G. B. Sharman and colleagues in the University of Tasmania were able to secure all but one of the listed species during 1950 and 1951, and to add two more new records, one being Erichson's long-lost *Moraba viatica* (Eumastacidae).[1]

An annotated list of the Acridoidea definitely known to occur in Tasmania is presented in Table 1. The taxonomy of the group in Australia as a whole is in an unsatisfactory state, although a comprehensive revision is at present being undertaken by James A. G. Rehn, of Philadelphia. As a consequence, a number of the names here used may need to be changed in the not-too-distant future. Those names that may be regarded as firmly established, as a result of work of Rehn and the author now in press, are rendered in bold-face type. It should be emphasised that, while some of the *names* are thus in doubt, there is no question about the distinctness of the species listed, nor about their occurrence in Tasmania. Dr. Rehn has kindly agreed to refer to the present paper in his treatment of any species the names of which will be changed, as a result of his work, from those here given. By this means it will be possible for this list to be brought progressively up to date as regards nomenclature, as the successive sections of Rehn's study are published.

It will be seen that the total number of species is 29, of which five are undescribed—two of them belonging to undescribed genera. The Tetrigidae are represented by two species and the Eumastacidae by one, while the remaining twenty-six belong to the Acrididae. The list more than doubles the number of species previously recorded in the literature. However, a number of the new records were already represented in museum collections in 1948; those in the Tasmanian Museum, Hobart, and the Tasmanian Department of Agriculture have been examined by the author. Six of the species are restricted in their distribution to Tasmania, and of these three are undescribed. *Moraba viatica* Erichs. and *Kosciuskola* sp. n. are doubtfully distinct from species occurring on the Australian mainland.

It is unlikely that many species of Acridoidea remain to be recorded from Tasmania. These insects are relatively conspicuous and active; and in suitable habitats quite numerous; the intensive collecting of the last few years should have brought the great majority to light. However, this collecting has been carried out chiefly in the mid-summer months. The two species (*Moraba viatica* and *Urnisa rugosa*) that were missed by the C.S.I.R.O. expeditions and later found by G. B. Sharman and his colleagues appear to be confined to the spring and early summer; any unrecorded species may well have a similar early season.

1 The credit for the rediscovery of *Moraba viatica* should actually go to Mr. B. A. B. Edwards, at that time attached to the Zoology Department, University of Tasmania, who collected the first specimens since Schayer.

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SJÖSTEDT, Y., 1935.—Revision der australischen Acridiodeen. 2. Monographie. *K. Svenska VetenskAkaa Handl.* (3), 15, 1-191, 2 pls.

Pap. & Proc. Roy. Soc. Tasmania, Vol. 86. (15th September, 1952)

The Cytology of Athrotaxis

By

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WITH 1 TEXT FIGURE

Summary

On the grounds of morphology and distribution, it has been suggested that *Athrotaxis laxifolia* is a hybrid between *A. cupressoides* and *A. selaginoides*. To test this hypothesis the cytology of the genus was investigated. All three species of *Athrotaxis* have 2n = 22 chromosomes in somatic cells and n = 11 in pollen grains. Meiosis is normal in all three species. No conclusive evidence that *A. laxifolia* is a hybrid was found. A final decision on the taxonomic status of *A. laxifolia* must await the results of breeding experiments.

1. Introduction

The genus *Athrotaxis* Don (1839) is an endemic Tasmanian genus of the family Taxodiaceae (Coniferae). Three species have been described. Two of these, *A. cupressoides* Don ('Pencil Pine') and *A. selaginoides* Don ('King Billy Pine') are markedly different from one another and plentiful in their native habitats, often forming pure stands. The third, *A. laxifolia* Hooker, is intermediate in size of leaves and cones between the first two species, and is comparatively rare. It is usually found as isolated trees near stands of one or both of the other two species.

These facts have given rise to the opinion that *A. laxifolia* is a hybrid between *A. cupressoides* and *A. selaginoides* (R. E. Smith, unpub.). In order to test this theory and also to provide further evidence on the relationships between the genera of the Taxodiaceae (Stebbins, 1948), I have investigated the cytology of all three species.

The life-histories of *A. selaginoides* and *A. cupressoides* have been studied by Saxton and Doyle (1929) and Elliott (1951) respectively, but no account of *A. laxifolia* or any observations on the chromosomes of the genus have been published.

FIG. 1.—Mitotic metaphase in root tip of *Athrotaxis selaginoides*.
FIG. 2.—First meiotic metaphase in p.m.c. of *A. cupressoides*.
FIG. 3.—First meiotic metaphase in p.m.c. of *A. laxifolia*.
FIG. 4.—First meiotic metaphase in p.m.c. of *A. selaginoides*.
FIG. 5.—First meiotic anaphase in p.m.c. of *A. laxifolia*.
FIG. 6.—First meiotic anaphase in p.m.c. of *A. cupressoides*.
p.m.c., pollen mother cell.

Reports on chromosome studies of the other members of the family Taxodiaceae have been published by a number of authors. (See Table 1). It would appear that the remaining two genera, *Cunninghamia* and *Glyptostrobus*, have not been counted.

TABLE 1

Chromosome Numbers in the Taxodiaceae

Species	Chr. No.	Author
Athrotaxis cupressoides	2n = 22	Gulline (this paper)
Athrotaxis laxifolia	2n = 22	Gulline (this paper)
Athrotaxis selaginoides	2n = 22	Gulline (this paper)
Cryptomeria japonica	2n = 22	Sax and Sax (1933)
Metasequoia glyptostroboides	2n = 22	Stebbins (1948)
Sciadopitys verticillata	2n = 20	Tahara (1937) (cited by Stebbins, 1948)
Sequoia sempervirens	2n = 66	Stebbins (1948)
Sequoiadendron giganteum	2n = 22	Buchholz (1939, *a*, *b*); Jensen and Levan (1941)
Taiwania cryptomerioides	2n = c. 22	Sax and Sax (1933)
Taxodium distichum	2n = 22	Stebbins (1948)

2. Materials and Methods

A summary of the localities from which material of each species was obtained and the stages observed in that material is given in Table 2.

Cuttings of *A. cupressoides* and *A. laxifolia* rooted after being kept in moist sand, with bottom heat, for three months. Root tips were squashed and stained in aceto-orcein or fixed in 2BE, sectioned at 20μ and stained in crystal violet.

Branchlets of all species bearing young male cones were collected from as many localities as possible from May 13th 1951 onwards. It was found possible to keep these alive in jars of water in the laboratory where the development of the young cones progressed at a more rapid rate than in trees growing in their natural habitat. Thus meiosis was first observed in the laboratory some six weeks before it occurred in the field. The microsporangia were squashed and stained in aceto-orcein.

Details of the methods used are given by Darlington and La Cour (1947).

Drawings were made with a camera lucida at an initial magnification of 3150X and reduced to 1575X for publication.

TABLE 2

Materials and Localities

Species	Locality	Material	Stages Observed
A. cupressoides	National Park	Seedlings	Mitosis in root tips
	National Park	Branchlets	P.m.c. meiosis to mature pollen
	Pine Valley	Branchlets	P.m.c. meiosis to mature pollen
	Hartz Mountains	Branchlets	Mature pollen
A. laxifolia	National Park	Cuttings	Mitosis in root tips
	National Park	Branchlets	P.m.c. meiosis to mature pollen
	Cradle Mountain	Branchlets	P.m.c. meiosis to mature pollen
A. selaginoides	National Park	Branchlets	P.m.c. meiosis to mature pollen
	Wyld's Craig	Seedlings	Mitosis in root tips
	Cradle Mountain	Branchlets	P.m.c. meiosis to mature pollen
	Hartz Mountains	Branchlets	Mature pollen
	Snowy Mountains	Branchlets	Mature pollen

Abbreviation:—P.m.c., pollen mother cell.

3. The Cytology of *Athrotaxis*

The resting nuclei of *Athrotaxis* regularly have two nucleoli. At mitotic metaphase, 22 chromosomes can be counted in the vegetative cells of all three species. The chromosomes are all long and rod-shaped with median or sub-median centromeres (fig. 1). The chromosomes cannot be accurately measured in sectioned material as they rarely orientate themselves completely in the plane of the equatorial plate. The arms are usually lying parallel to the long axis of the cell. Squashes proved unsatisfactory because of the large amounts of resinous materials present.

The course of meiosis is identical in all three species (figs. 2, 3, 4). At first metaphase, the 22 chromosomes almost always form 11 pairs with 1-3, usually two, chiasmata. Failure to pair was observed in one plant only, of *A. cupressoides* (see fig. 2). The appearance of the bivalents is exactly like that of other Conifers illustrated by Sax and Sax (1933). The chiasmata are usually interstitial or sub-terminal. The frequency of chiasmata per pollen mother cell is given in Table 3. This chiasma frequency is lower than that for many other Conifers (Sax and Sax, 1933). In each species the figures were calculated from 10 cells, i.e., 110 bivalents.

At first anaphase, the chromosomes segregate regularly, and the median or submedian positions of the centromeres become obvious (figs. 5, 6). There is a short resting stage between the first and second divisions, during which it can be seen that the cytoplasm has divided into two parts but no cell wall is formed between the two daughter nuclei. The second division results in the formation of four haploid nuclei arranged tetrahedrally within the pollen mother cell wall. The young microspores then develop cell walls and before shedding undergo a division so that at maturity each pollen grain is bicellular, as described by Elliott (1951). During 1951, in *A. cupressoides* meiosis occurred in the field in mid-July, and pollen was shed in early September, about six weeks later. The corresponding stages occurred in *A. laxifolia* approximately a week later, and in *A. selaginoides* about four weeks later, than in *A. cupressoides*. The mature pollen grains are spherical and show no obvious differences between the three species. The fertility of the pollen is given in Table 3. The estimates are based on counts of 200-300 pollen grains from mature cones of one tree of each species.

TABLE 3

Species	P.M.C. Meiosis: Chiasmata per cell	P.M.C. Meiosis: Mean Chiasmata per bivalent	% Pollen Fertility
A. cupressoides	21·00 ± 0·39	1·91	95·0
A. laxifolia	20·90 ± 0·40	1·90	87·73
A. selaginoides	21·20 ± 0·32	1·93	96·7

4. Relationships Within the Taxodiaceae

The basic number of chromosomes found almost uniformly throughout the Taxodiaceae is x = 11. Comparison of illustrations of the chromosomes of *Athrotaxis* (this paper), *Cryptomeria japonica* (Dark, 1932), *Metasequoia glyptostroboides* (Stebbins, 1948), and *Sequoiadendron giganteum* (Jensen and Levan, 1941) shows that the group is a very uniform one in size and morphology, as well as in number, of chromosomes. It appears that in the course of evolution, the differentiation of the genera has progressed chiefly through gene mutations unaccompanied by changes in the number or gross morphology of the chromosomes.

A notable exception to this generalisation is *Sequoia sempervirens* which is a polyploid with 6x = 66 chromosomes. On the basis of vegetative characters, Stebbins (1948) put forward the theory that it is descended from a cross between an ancestor of the diploid *Metasequoia* and another species closely related to either *Sequoiadendron, Taiwania,* or *Athrotaxis.* The chromosome numbers of these genera make this relationship theoretically possible. The present view of paleontologists, however, (Florin, 1940) is that *Athrotaxis* has always been restricted to the Southern hemisphere, and all the other Taxodiaceae to the Northern hemisphere. It is therefore improbable that *Athrotaxis* has taken any part in the evolution of *Sequoia sempervirens.*

5. The Status of *Athrotaxis laxifolia*

It is difficult to reach any conclusion on the origin of *A. laxifolia* from cytological studies alone. As can be seen from the text-figures the chromosomes of *A. cupressoides* are indistinguishable from those of *A. selaginoides.* Thus *A. laxifolia* would be expected to have 22 long, metacentric chromosomes whether it is a hybrid between the two other species or a " good " species of independent origin.

The course of meiosis in *A. laxifolia* is similar to that of any normal diploid plant. The frequency of chiasma formation is not significantly different from that of the other species and the chromosomes segregate normally at anaphase. The pollen resulting from the pollen mother cell divisions also appears normal in all respects. This is evidence, although not conclusive, that *A. laxifolia* is not a hybrid. It is possible for a hybrid between two closely related species to undergo meiosis in a normal manner and to produce fertile pollen (Darlington, 1937). Sax and Sax (1933) record that many Conifer species hybrids show regular chromosome pairing, normal chiasma frequency at meiosis and a high degree of fertility. It is however possible that many of these " species " should properly be regarded as geographical subspecies.

In the field, *A. cupressoides* and *A. selaginoides* are found in different ecological habitats, although not necessarily growing further apart than their wind-borne pollen could be carried to effect a cross between them. However, in the season these observations were made, the flowering seasons of these species did not overlap. It is possible that in other years, altitudinal variations in flowering time might make natural hybridisation possible.

It is known that *A. laxifolia* forms female cones which develop to maturity and dehisce, but no records of the viability of the seed or of any progeny are known to the author. Final proof whether *A. laxifolia* is a hybrid or not can be made only by re-creating the species artificially or observing the occurrence of segregation of specific characters of *A. cupressoides* and *A. selaginoides* in the progeny of *A. laxifolia*.

6. Acknowledgments

I wish to thank Professor H. N. Barber for his helpful advice. The work was carried out in the Botany Department of the University of Tasmania while I was in receipt of a Commonwealth Research Grant. I also wish to thank Major R. E. Smith for permission to quote his observations, the Scenery Preservation Board of Tasmania for permission to collect material of these plants from the National Parks, and the many interested persons who assisted by collecting material.

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The Royal Society of Tasmania

Volume 86

Patron:
His Majesty the King.

President:
His Excellency Admiral Sir Hugh Binney, K.C.B., K.C.M.G., D.S.O., (until May, 1951).
His Excellency Rt. Hon. Sir Ronald Cross, Bt., (from August, 1951).

Vice-Presidents:
S. W. Carey, D.Sc., 1951.
J. W. C. Wyett, B.Sc., A.A.C.I., 1951, 1952.

Council:
A. L. Meston, M.A., 1951, 1952, 1953.
L W. Miller, M.Agr.Sc., F.R.E.S., 1951, 1952, 1953.
W. L. Crowther, D.S.O., M.B., F.R.A.C.P., 1951, 1952.
M. S. R. Sharland, 1951, 1952.
W. H. Hudspeth, B.A., 1951.
F. C. Wolfhagen, LL.B., 1951.

Hon. Secretary and Librarian:
Joseph Pearson, D.Sc. (Manchester), D.Sc. (Liverpool), F.R.S.E., F.L.S

Assistant Hon. Secretary:
D. Martin, M.Sc.

Hon. Treasurer:
S. Angel.

Hon. Auditor:
A. M. Hewer.

Hon. Editors of the Papers and Proceedings:
Joseph Pearson and D. Martin.

Standing Committee:
W. L. Crowther, S. W. Carey, W. H. Hudspeth, J. Pearson, D. Martin.

Annual Report, 1951

The Annual Meeting was held in the Society's Room, Tasmanian Museum and Art Gallery, on the 13th March, 1951.

In the absence of His Excellency the Governor, President of the Society, Mr. A. L. Meston (Vice-President) presided.

The following Office-bearers were elected:—

Vice-President: Under the Society's Rules Mr. A. L. Meston retired from the office of Vice-President, and Mr. J. W. C. Wyett was appointed in his place (retiring 1953).
Hon. Secretary and Librarian: Dr. Joseph Pearson.
Hon. Assistant Secretary: Mr. D. Martin.
Hon. Treasurer: Mr. S. Angel.
Hon. Auditor: Mr. A. M. Hewer.
Council: *Under Rule* 21 Mr. J. W. C. Wyett and Mr. D. Martin retired as members of the Council and Mr. A. L. Meston and Mr. L. W. Miller were elected in their place for a period of three years.

The names of the full Council for 1951 are given on the previous page.

The Council made the following appointments at its first meeting:—

Assistant Librarian: Miss B. Veale.
Standing Committee: Dr. W. L. Crowther, Professor S. W. Carey, Mr. W. H. Hudspeth and the Hon. Secretary.

Tasmanian Museum and Botanical Gardens

In the report for 1950 it was announced that the Board of Trustees which administered the Tasmanian Museum and Botanical Gardens jointly had been replaced by two new Boards, one to administer the Tasmanian Museum and Art Gallery and the other to administer the affairs of the Botanical Gardens. Actually the change over did not take place until 1st March, 1951. This change is a matter of supreme interest to the Society since both the Tasmanian Museum and the Botanical Gardens were administered by the Society up to the year 1885, and since that date the Society has been represented on the Board of Trustees which administered the two Institutions. It is satisfactory to note that this connexion will be maintained and the two new Acts which are now in force make provision for the appointment of representatives of the Society to serve on the two Boards; that is to say, two representatives on the Board of Trustees of the Tasmanian Museum and one representative on the Board of Trustees of the Botanical Gardens. It is particularly important that this vital link should be maintained in the case of the Tasmanian Museum since the Royal Society is entitled to the use of a room in the Museum for its Library and for its meetings. It is important, too, to emphasize the value of the Society's Library to the scientific workers in the Museum. In fact, it would be almost impossible to do any valuable scientific work in the Museum without the help of the Society's Library. The Society's representatives for 1951 were as follows:—Board of Trustees of the Tasmanian Museum: Mr. W. H. Hudspeth and Professor T. Hytten. Board of Trustees of the Botanical Gardens: Mr. S. Angel.

Meetings

Nine ordinary and two special meetings were held during the year.

In connexion with the celebration of the Jubilee of Federation of the Commonwealth of Australia the Society arranged a special evening on 1st May, at which Mr John Reynolds gave a paper on "The Building of the Australian Federation". On this occasion our President, Sir Hugh Binney and Lady Binney were present and members were given the opportunity of saying farewell when coffee was served in the Art Gallery after the lecture. Professor Carey, who presided at the meeting, spoke on behalf of the members and conveyed to them the best wishes of the Society for their retirement.

The Clive Lord Memorial Lecture was delivered by Professor J. Burke, Professor of Fine Arts at the University of Melbourne, on 19th November. About 250 members and guests were present and the function was followed by a conversazione when coffee was served. Advantage was taken of this occasion to induct the new Governor, the Rt. Hon. Sir Ronald Cross, Bt., as President of the Society. Lady Cross was also present.

Library

This year the periodicals were revised. This involved an increase of 670 volumes in the Accession Book, together with a further 450 which were new accessions by the purchase of books or received by way of exchange from various institutions. The number of Institutions on the exchange list is now 296 and new exchanges have been arranged with the following institutions: National Gallery of Canada; Societatis Zoologicae Botanicae Vanamo, Helsinki; Services des Exchanges de la Société Royale Zoologique de Belgique; Museum für Natur-Völker und Handelskunde Bremen; Zoologisch-Botanischen Gesellschaft in Wien; Museu Dr. Alvaro de Castro, Portugal; Service de la Pêche et de la Chasse en Indochine; Ministerio de Educacion de la Nacion, Universidad Nacional de Tucaman, Argentine, South America; Department of Mines and Technical Surveys Geographical Branch, Canada; Fisheries Research Board of Canada.

The Library now consists of 25,515 volumes.

Changes in Staff

Owing to the fact that Miss B. Veale had been transferred from the staff of the Society's Library to the University Library, as stated in last year's report, her place as Assistant Librarian has been filled by Miss Jenny Robertson.

Membership

The Society consists of the following members:—

Honorary members		3
Corresponding members		2
Ordinary members:—		
Class A	239	
Class B	145	
		393
Life members		28
Associate members		18
		444

During the year 26 names were removed from the List of Members owing to deaths, resignations, &c., and 48 new Ordinary Members were elected. Two Associate Members became Ordinary Members.

Honorary Member

At the meeting on 27th August, Mr. W. E. Masters was elected an Honorary Member of the Society under Rule 45. Mr. Masters has made notable contributions to the early history of Tasmania, particularly regarding the waterfront of Hobart and the Semaphore Telegraphic System of early Tasmania. His work has always been distinguished for accuracy and thoroughness and has contributed largely to the diffusion of knowledge and interest in Tasmanian history, especially in regard to the history and development of the Hobart waterfront on which he is an acknowledged authority.

Deaths

The year 1951 was marked by the deaths of some very distinguished members of the Society amongst whom may be counted Mr. A. L. Meston, Professor L. F. Giblin, Miss A. L. Wayn, Dr. W. W. Giblin, as well as Mr. D. V. Allen, Mr. S. V. Sydes and Miss J. Robinson.

Death of Sir Ernest Clark, G.C.M.G., K.C.B., C.B.E.

We regret to have to record the death of Sir Ernest Clark, who was Governor of Tasmania from August, 1933, to August, 1945. Apart from his official duties as Governor, Sir Ernest Clark was outstanding in his duties as President of our Society. Out of aproximately 108 meetings which were held during his term of office he actually presided at 70. Although without scientific training he was a keen student of public affairs and generally contributed something important to the Society's discussions.

Finance:

During the year the Council was greatly concerned about the financial position of the Society. This had been brought about by the rapid rise in the cost of living. A time had been reached when it might be said that the Society was living beyond its income and the Council, after having considered the matter very carefully, were forced to the conclusion that the only remedy was to increase the subscriptions for membership. At a special meeting of the Society which was called for 20th December, 1951, it was decided to increase the subscriptions from 1st January, 1952, as follows:—

Life Membership, increased from £20 to £25.
Ordinary Membership (for those who receive the Papers and Procds.), increased from £1 10s. to £2.
Ordinary Membership (for those who do not receive the Papers and Procds.), increased from £1 1s. to £1 10s.
Associate Membership, increased from 10s. to 15s.

Consolidation of Rules

Since the last revision of the Rules of the Society many further revisions had been made and a stage had been reached when the Council considered that the Rules should be revised and consolidated. A Sub-Com-

mittee was appointed to examine this question and to report to the Council and, finally, at a Special Meeting of the Society held on 22nd August, 1951, the Council submitted the consolidated Rules for the approval of Members. This was approved.

Printing of Papers and Proceedings

The Printing Vote was increased from £400 to £600 to meet the higher cost of production. The Council wishes to express their gratitude to the Government for this generous action.

The Council also wishes to thank the University Authorities for having made a contribution, through Professor Hickman, of £70 towards the cost of printing certain papers from the Department of Zoology.

Gifts to the Society

The following is a list of gifts to the Society during the year, in addition to the numerous exchanges received from British and Foreign Institutions:—

Warrant signed by Queen Victoria and addressed to Sir Henry Edward Fox Young, authorizing him to issue to Francis Smith Letters Patent as Attorney-General of Tasmania: Miss J. Hudspeth through Mr. W. H. Hudspeth.

Letters written by Louisa Ann Twamley, who married Mr. Charles Meredith, and photograph of Louisa Ann Twamley: Mrs. W. O. G. Johnson, Queensland.

Typescript of Thesis on Mrs. Charles Meredith: Miss J. Buchanan.

Photostat copies of documents and photographs of the Irish Exiles of 1848: Presented by the Ambassador of Ireland through Mr. J. E. Heritage.

Old account books of the Derwent Bank: Mr. L. Nettlefold.

Notes on excavation of aboriginal rock carvings at Mt. Cameron West; by L. E. Luckman. (An abstract of this account, including a selection of photographs taken by Mr. and Mrs. Luckman, was published in the Papers and Proceedings for 1950).

"Entally", by K. R. von Stieglitz: Scenery Preservation Board.

"Peaks and High Places", by I. R. Boss-Walker: Scenery Preservation Board.

"The Settlers in V.D.L.", by W. Gellie: Presented by the Author.

"Historical Brevities of Tasmania", by J. Moore-Robinson. Presented by Mr. E. R. Pretyman.

"A Short History of Sheffield, &c.,", by K. R. von Stieglitz: Presented by the Author.

The Royal Society of Tasmania.

State of Receipts and Payments for Year ended 31st December, 1951.

Receipts.

	£	s.	d.	£	s.	d.
Balance from last account				38	15	10
Subscriptions—						
£1 10s.: 230 + 3/3	345	3	3			
£1 1s.: 149 + 9/-	156	18	0			
10s.: 18	9	0	0			
£20: 1	20	0	0			
				531	1	3
Rentals				52	9	10
Sale of Publications				12	14	11
Transferred from Reserve Fund				130	0	0
University of Tasmania (Zoology Dept.), contributed to Papers and Proceedings				70	0	0
Transferred from Funds for Books				23	13	6
				£858	15	4

S. Angel, Hon. Treasurer.
A. R. Hewer, Hon. Auditor.

Payments.

	£	s.	d.
Salaries	195	12	2
Library	121	18	1
Lighting	76	12	11
Stationery, printing, &c.	54	1	4
Miscellaneous	29	8	3
Northern Branch, share of subscription, 1950	69	7	2
Equipment	7	19	3
Insurance	27	7	6
Transferred Reserve Fund, sale of publications	50	4	11
Expenses, Clive Lord Memorial Lecture	32	18	4
Transferred Life Membership Fund	20	0	0
Purchase papers and photographs, N. Oldham	31	10	0
Petty Cash (balance to next account 17/8½)	67	0	0
	783	19	11
Balance to next account	74	15	5
	£858	15	4

S. Warren Carey, Vice-President.
Joseph Pearson, Hon. Secretary.

Royal Society Funds.

Statement of Balances for Year ended 31st December, 1951.

	£	s.	d.
Reserve Account	31	9	5
Life Membership Account	252	7	9
Clive Lord Memorial Fund (£200)	16	16	6
R. M. Johnston Memorial Fund (£232)	0	2	5
Morton Allport Memorial Fund (£200)	0	2	10
A. H. Clarke Bequest (£100)	0	5	3
Milligan Bequest (£150)	0	7	0
A. N. Lewis Memorial Fund (£250)	28	3	10

Abstracts of Proceedings

13th March, 1951

Annual Meeting

The Annual Meeting was held in the Society's Room, Tasmanian Museum. Mr. A. L. Meston, Vice-President, presided.

The following Office-bearers were elected for 1951:—Mr. J. W. C. Wyett was elected Vice-President in the place of Mr. A. L. Meston, who retired under Rule 12; Honorary Secretary, Dr. J. Pearson; Assistant Honorary Secretary, Mr. D. Martin; Honorary Treasurer, Mr. S. Angel; Honorary Auditor, Mr. A. M. Hewer.

The following were elected members of the Council for 1951: Mr. A. L. Meston and Mr. L. W. Miller were elected for three years in the place of Mr. J. W. C. Wyett and Mr. D. Martin who retired under Rule 21.

The following were elected members of the Society:—Miss P. H. Perkins, Mrs. Lucy Fletcher, Miss G. Whitfield, Mr. J. C. Murray, Mr. H. G. Pitt.

Mr. I. G. Anderson presented to the Society, on behalf of Mr. W. Gellie, a bound typescript containing the names of the settlers who arrived in Van Diemen's Land between the years 1804 and 1835. Dr. Crowther, who was absent owing to illness, sent a letter to the Chairman in which he referred to the typescript. The gift was accepted by the Chairman on behalf of the Society and the Secretary was instructed to send a letter of thanks from the Society to Mr. Gellie.

Mr. L. W. Miller delivered a lecture entitled "Post-war Development in Pest Control" of which the following is an abstract:—

> Since the second World War there has been a striking increase in the numbers of new insecticides. These new materials are all organic chemicals and have largely replaced the inorganic chemicals formerly used as insecticides.
>
> The most used of the new chlorinated compounds is DDT. Others coming into prominence in Australia are benzene hexachloride and chlordane.
>
> The other major group of new insecticides are the organo-phosphorous compounds such as H.E.T.P., T.E.P.P. and Parathion. More recently there have been developed the compounds within this group that show systematic properties.
>
> The implications of all these new insecticides on economic entomology were touched on.

3rd April, 1951

A meeting was held in the Society's Room. Professor S. W. Carey, Vice-President, presided.

The following were elected members of the Society:—Mr. D. H. Borchardt, Mr. B. J. Dempsey, Mr. R. J. Ford, Mr. J. L. Hickman, and Mr. H. J. Turner.

Dr. J. B. Polya delivered an illustrated lecture entitled "Chemo-Therapy of Cancer" of which the following is an abstract:—

> Cancer is not a single disease but a group of diseases characterized by malignant neoplasms. The criteria of malignancy are the ability to form metastases and a total or far going freedom from the control of organizers. A characteristic feature of cancer is a tendency towards the loss of special-

ization in the affected tissues. This tendency towards uniformity applies to individual cases only and the direction of this tendency varies from case to case.

Physical, chemical, biological and psychological methods, are being used in the treatment of cancer. Physical methods such as surgery and radiological techniques, are the most reliable at present. All chemical methods of treatment may not be classified as chemotherapeutic ones; nostrums have psychological effects only, "chemical surgery" is undesirable and the large number of ethical drugs used in the treatment of cancer assist the surgeon and the radiologist without striking at the root of the disease. True chemotherapeutical agents are expected to remove deficiencies, excess secretions, poisons and foreign bodies directly responsible for the disease. While chemical cures or improvement of cancer have been effected, it is not possible to claim that a certain percentage of any particular type of cancer can be cured by chemotherapy.

It is improbable that deficiencies, e.g., those of magnesium or vitamins, cause cancer and attempts to correct such deficiencies have not led to reliable cures of cancer. Low cobalt: nickel ratios are possibly correlated with the high incidence of malignant leukemias in Tasmania, but this requires further confirmation. As to dietary excesses, recommended starvation diets are more absurd than useful and it appears that the effect of diet is more pronounced on the cancerous than on the precancerous state.

Polycyclic tar hydrocarbons and azo-dyes may be used for the experimental production of cancer; some industrial cancers are due to such causes. At the same time some members of these carcinogenic classes, especially the weaker ones, may be used to inhibit tar cancer.

In the case of hormones, the notions of deficiency and excess are of little use. Much evidence on the correlation between cancer and hormonal levels (or the levels of metabolites governed by hormones) is contradictory. Tumours of the prostata may be controlled and occasionally cured by the administration of natural or synthetic oestrogens although this treatment may lead to complications. The formation of mammary cancers is delayed or inhibited by androgens which, however, cannot cure mammary cancers.

Cancer is not due to bacteria. The existence of Bittner's milk factor and the transfer of cancer through cell-free filtrates indicate that a virus may be involved but the lack of cancer epidemics and the delayed action of the virus indicate that the controlling factor in the viral production of cancer is the accommodation of the virus within living cells. Such a process would amount to a mutation if the cancer virus were assumed to act either as a supernumerary gene or as a substitute for a gene and if such an alteration of an originally normal cell were stable enough to be perpetuated through the mitotic process. The most promising methods of chemotherapy are based on this picture of a mutant cell acting as a foreign organism.

Drugs slowing down cell growth are expected to control the rapid cancerous growth. Colchicine is satisfactory from a cytological point of view but too toxic for therapeutic purposes. Some compounds related to the old colchicine structure, now recognized to be inaccurate, including synthetic substances related to stilboestrol and the chelidonium alkaloids are being studied. This work is promising but has not yet yielded significant results. Since the colchicine effect has been correlated with narcotic effects, some narcotics have been tried. Some urethanes and, to a lesser extent, benzene have some effect against leukemias but may give rise to other forms of cancer. Arsenical preparations have similar uses and dangers. Bacterial toxins have some selective effect against cancer but they are too toxic and tumours may develop immunity towards them. It is suggested that Apolant's work on eosine-selenium compounds be resumed since his early work indicates that such materials have a great selective toxicity for cancer cells.

Inhibition of nucleic acid synthesis through the competition of alpha methopterin with folic acid or 2, 6-diaminopurine with adenine and guanine has given promising preliminary results.

Mustard gas and the nitrogen mustards inhibit mitotic processes presumably through cross linkages between vital protein chains but similar effects on other proteins result in excessive general toxicity. Derivatives of ethyleneimine and ethylene oxide were expected to display antimitotic effects. Experimental work confirmed this prediction in a number of cases. Further extension of these theories has led to the investigation of some 1, 2, 4-

triazoles in Tasmania. Some compounds of the latter class have powerful antimitotic effects and 1-phenyl-3, 5-dimethyl-1, 2, 4-triazole powerfully inhibits C3H tumours of mice.

According to Potter cancer arises through the transformation of an unknown enzyme into a virus through carcinogens. Inhibition of the critical enzyme by co-carcinogens leads to a lowering of the enzyme : virus ratio to a value at which the symptoms of cancer appear. The enzyme might be succinic dehydrogenase or a closely related aerobic enzyme which is in good agreement with a number of observations, including the inhibition of cancer by methylene blue or pyocyanine.

Effective chemotherapeutic agents against cancer may be expected in the near future although it is probable that their usefulness will be restricted to particular types of cancer.

1st May, 1951

Jubilee Meeting

A meeting was held in the Society's Room. The meeting was arranged as part of the celebrations of the Jubilee of Federation. Professor S. W. Carey, Vice-President, presided.

The following were elected members of the Society:—Miss E. Cornelius, Mr. L. A. Hoare, Mrs. H. R. Evershed, Miss M. Wilson, Mr. Donald Cameron, Mr. B. R. Ellis, Mr. N. A. Findlay, Mr. John Lord, Mr. Allan T. Orr, Mrs. M. Padman.

Professor Carey, as Chairman, addressed the meeting regarding the imminent departure of His Excellency the Governor (President of the Society) and Lady Binney at the termination of his period of office as Governor of Tasmania. Professor Carey drew attention to the valuable work which both the Governor and Lady Binney had done for the community during their residence in Tasmania.

In reply His Excellency thanked Profesor Carey and the Society for giving him and Lady Binney the opportunity of saying farewell to members of the Society.

Mr. J. Reynolds delivered a lecture entitled " The Building of the Australian Federation ", of which the following is an abstract:—

It is fitting that the Royal Society of Tasmania should meet to celebrate the Jubilee of the Commonwealth of Australia. A number of the Society's members made valuable contributions to the building of the Federation:— Sir Edward Braddon, Sir Adye Douglas, Sir Neil Eliot Lewis, the Honourables Andrew Inglis Clark, Nicholas John Brown, and Charles Henry Grant were Tasmanian delegates to the Constitutional Conventions; Sir Herbert Nicholls, Messrs. Frederick William Piesse, and William Frederick Dennis Butler were leading members of the Federation League. And I am happy to see Mr. Wilfrid H. Hudspeth with us on this occasion. Mr. Hudspeth was a tower of strength to the Federalist cause as President of the Hobart Branch of the Australian Natives Association during the period of the Referendum campaigns for the adoption of the constitution.

Many and various causes operated both for, and against, the building of the Australian Federation. It is my purpose to-night to endeavour to mention one of the principal forces known to historians to-day.

Tasmania was the first colony to secure administrative independence from New South Wales. On December 3rd, 1925, the Royal Society commemorated the centenary of the separation with a dinner which was held in the old meeting room. Western Australia was founded four years later and was never subject to the Government at Sydney. In 1836, South Australia was established as a Province and not a colony, which was likewise governed by the Colonial Office. Victoria became a separate colony in 1851 and Queensland in 1859. Unfortunately when the Colonies received their grants of responsible representative government (1855-56), no provision was made in their constitutions for uniform action upon vital matters of mutual concern.

As early as 1848, the then Colonial Secretary (Earl Grey), had endeavoured, unsuccessfully, to form a federal union by an Act of the Imperial Parliament. His scheme was rejected through indifference in England, and violent opposition in all the colonies. In spite of the untiring efforts of leading Australian Statesmen, such as Sir Edward Deas-Thomson (N.S.W.), William Charles Wentworth (N.S.W.), Charles Gavan Duffy (Vic.), and George Higinbotham (Vic.), the colonists were determined to remain divided. For at least thirty years after the separation of Queensland (1860), the governing classes in England seemed by their indifference, to favour these separatist policies. " The little Englanders ", the Manchester School disciples and the powerful Radicals all looked coldly upon any forward colonial policy. This situation was unchanged until Joseph Chamberlain became Colonial Secretary (1895), when the Federation Movement was well under way.

In these circumstances it is not surprising that the forces of Provincialism took command of colonial politics. The six colonies each provided themselves with practically the whole apparatus of civilised government. As these were unrelated and mostly unco-ordinated, great confusion, delay, and economic loss resulted. The greatest difficulty was the Tariff problem. Every colony at one time and another, during this period, raised customs barriers against its neighbours. In spite of the amazing number of conferences which were held to try and reach agreement, Federation in 1901 found them still squabbling. Matters were little better in respect to Postal Administration, Quarantine, Marine Regulations, Immigration and Legal Processes. The defence position was almost Gilbertian, there being at one period six little armies having different commands, arms, and uniforms. Naval defence after 1888 was slightly better as the Australian colonies and New Zealand were in that year brought into a general Imperial defence scheme. There had been some united action in support of Queensland's occupation of New Guinea (1881-82) to forestall Germany, but even encroachments of foreign powers, and Russia War scares (1885-90) failed to awaken the provincially minded politicians.

I am putting forward the theory this evening that it was the awakening and pressure of an Australian Nationalist public opinion that defeated the forces of Provincialism and made Federation possible. I feel that there is much evidence in support of this theory. The foundation (1871) and rapid growth in power and influence of the ' Nationalist ' Australian Natives Association was something new to the colonies. Its members, native born Australians, were untiring missionaries for the idea of a Nation, rather than six squabbling colonies. In 1880, the Sydney Bulletin appeared. This journal soon achieved an importance out of all proportion to its circulation because it made Australian Nationalism and self-reliance its unshakable policy. It encouraged Australian writers, poets and artists on a scale hitherto unknown in journalism.

Sir Henry Parkes (the Father of Australian Federation) took up the cause of Union at a very early stage of his long political career. Between the years of 1860 and 1880, when the ridiculous tariff wars were at their height he used every opportunity to preach the federal gospel. His idea of a Federal Council was finally adopted and met for the first time in Hobart in 1886. It was too limited and powerless for his purposes. In 1889, Sir Henry saw his opportunity, and at Tenterfield (N.S.W.), made an historic appeal to the Australian people to unite and become a nation. This speech was the starting point of the Federation Movement. As I view this movement, I see it sweeping aside all the Provincial, sectional and local interests and carrying public opinion with it towards a national ideal. I claim that it was the existence of a national sentiment which made this possible.

The leaders of the movement adopted national phrases in making their appeal for support. Sir Henry Parkes coined the phrase, " One People, One Flag, One Destiny " (this was adopted as the motto of the Federation Leagues).

His successor in leadership, Sir Edmund Barton, was the author of the oft-repeated prophecy; that when Federation was achieved, " That, for the first time in history, there will be a nation for a continent, and a continent for a nation ". And Alfred Deakin enthusiastically described his countrymen as " Independent Austral-Britons ". Many other phrases and slogans could be quoted if time permitted. The Tasmanian, Andrew Inglis Clark, told the 1890 Federation Conference that he looked toward a " United Australia which will progress and flourish, and take its place among the nations of the world.

I have not discovered any other force which could be compared with Nationalism, as a means of achieving a national union of the colonies, whether by way of federation, confederation, or unification.

At the conclusion of this meeting the Council entertained His Excellency the Governor and Lady Binney to coffee and light refreshments in the Art Gallery. There were about 40 people present.

5th June, 1951

A meeting was held in the Society's Room. Mr. J. W. C. Wyett, Vice-President, presided.

The following were elected members of the Society:—Mr. A. M. Kilgour, Mr. J. B. Taylor, Mr. C. I. Wood, Mr. C. Pease.

Professor S. W. Carey delivered an illustrated lecture entitled "Industrial Power from Volcanoes".

3rd July, 1951

A meeting was held in the Society's Room. Professor S. W. Carey, Vice-President, presided.

The following were elected members of the Society:—Mr. R. S. Ellis, Mrs. J. H. Thyne, Mr. T. E. Burns, Mr. N. Hawkins.

Professor G. G. Firth delivered a lecture entitled: "Problems of Economic Research", of which the following is an abstract:—

A. Borderline Problems

Four main fields of economic research—

(1) Analysis of money flows and asset stocks in an economy.
(2) Behaviour of private economic units (households and business firms) in relation to market activities.
(3) Policies of governments and associated authorities (including central banks) in spending and taxing, altering the supply of assets and regulating the conditions of production and exchange.
(4) Measurement of "wealth and progress" in particular regions.

Of these fields (1) involves the co-operation of accountants; (2) that of psychologists, social anthropologists, production engineers and agricultural scientists; (3) that of political scientists; whilst (4) raises the profound philosophical difficulties associated with the measurement of "well-offness".

A research economist should have some knowledge of borderline problems in these fields and should be aware of the need to consult appropriate specialists when designing or interpreting his research.

B. Methods of Research

Impossibility of controlled experiment results in economists having to rely upon empirical correlations established by time series analysis. Relationships thus established are liable to change in the course of time. More frequent collection of data is desirable but expensive. The economist's problems here resemble those of the meteorologists.

Statistics are often collected as a by-product of administrative or commercial requirements. The research economist must be sceptical of published statistics and aware of their shortcomings. Random sampling techniques for collecting data have two main disadvantages: the absolute size of the sample must be fairly large, and the difficulty of avoiding "response bias".

Kinds of mathematics appropriate to economic research are only now being developed and are accessible to comparatively few economists.

C. Problems of Measurement

Quantitative economic studies often involve the use of aggregate values, involving a price component as well as a quantity component. To allow for changes in the value of money, aggregate values must be "deflated" by price index numbers. Unfortunately, the process of deflation involves a comparatively wide margin of error during times of acute monetary disturbance; yet these periods are of special importance for economic research.

The measurement of "welfare" between places and periods raises deeper philosophical problems, for the solution of which economic research can do little more than supply better and more plentiful information, as the basis for the normative judgments on which measurement of this kind ultimately depends.

D. Research Manpower

Review of the financial and other difficulties which at present make it almost impossible for State universities to attract research workers in economics who possess the necessary qualifications for effective original work.

7th August, 1951

A meeting was held in the Society's Room. Professor S. W. Carey, Vice-President, presided.

The following were elected members of the Society:—Mrs. V. E. Vimpany, Mr. T. R. Lorimer, Mr. S. L. Rennison, Mr. A. Weatherley, Commander F. D. Shaw, Mr. L. E. Wall, Mr. M. L. Yaxley.

Dr. Pearson explained that Lady Shoobridge had telephoned to him to the effect that fossilised trees had been uncovered during working operations on the road between Glenora and Gretna. Professor Carey had been immediately informed of this and members of the Geology Department at the University went out and examined the trees and took photographs. Specimens of the trees were exhibited at the meeting and Mr. M. R. Banks, Lecturer in Geology at the University, gave some notes of explanation. Sir Rupert Shoobridge also spoke.

Dr. A. G. Nicholls delivered a lecture entitled "Age and Growth of Trout from their Scales" of which the following is an abstract:—

The general structure and development of trout scales was described, and their relation to the growth of the fish explained. It was shown that summer and winter ring-formation is related to the food intake of the fish and not to temperature itself; this is only the indirect cause of variation in growth rate since the natural food supply depends on seasonal fluctuations.

Trout from the Lakes of Tasmania, where growth is good, show an anomaly in structure, in that the winter ring corresponding to the second year of the fish's life may be omitted. It is probable that the second ring laid down on the scale may correspond with the first occasion on which the fish spawns, usually the third year of life, as has been found elsewhere in Rainbow Trout.

27th August, 1951

A meeting was held in the Society's Room. Mr. J. W. C. Wyett, Vice-President, presided.

Mr. W. H. Hudspeth moved that "The meeting had learned, with deep regret, of the death of its former President, Sir Ernest Clark, G.C.M.G., K.C.B., C.B.E., and wishes to place on record its appreciation of his services to the Society". In moving this resolution, Mr. Hudspeth spoke of the great interest which Sir Ernest had shown in the Society's business and mentioned that he actually presided at 70 meetings during his term of office from 1933 to 1945.

The following were elected members of the Society:—Mr. R. C. Robertson. Hon. Member, Mr. W. E. Masters. On the recommendation of the Council Mr. W. E. Masters, B.A., LL.B., had been nominated for Honorary Membership of the Society at the last meeting. In supporting the nomination Mr. W. H. Hudspeth, on behalf of the Council, had outlined the reasons for which this proposal was being made and referred particularly to the valuable work which Mr. Masters had carried out over a period of years on the historical researches connected with the Hobart waterfront and with other aspects of early history.

Professor Ralph Grim, Research Professor of Geology, University of Illinois, U.S.A., delivered a lecture entitled: "The Composition and Properties of Clays and Soils".

27th August, 1951

A Special Meeting was held in the Society's Room at the conclusion of the General Meeting. Mr. J. W. C. Wyett, Vice-President, presided.

Dr. Pearson (Hon. Secretary) explained the reason for the meeting namely, to pass the consolidated Rules of the Society as proposed by the Council, and in moving the consolidation Dr. Pearson pointed out that there were very few alterations from the amendments which had already been passed by the Society at various special meetings and any alterations that had been made were for the purpose of clarifying rules or for abbreviating certain statements such as the schedule dealing with Medals and Awards.

2nd October, 1951

A meeting was held in the Society's Room. Professor S. W. Carey, Vice-President, presided.

The following exhibits were shown:—Self portrait of J. Glover; Picture by J. Glover purchased in London; Six coloured photographs of drawings by Tobin during Bligh's expedition to Adventure Bay in 1792.

Dr. Joseph Pearson delivered an illustrated lecture entitled "Recent Researches in Marsupial Comparative Anatomy and Embryology", of which the following is an abstract:—

> This abstract deals with some aspects of the investigations on marsupial anatomy and embryology which are being carried out at the Tasmanian Museum by the Lecturer in collaboration with Mr. de Bavay.
>
> Although in the early vertebrates the Wolffian duct and Müllerian duct arise simultaneously by the splitting of the pronephric duct, there is a considerable time-lag in the formation of the Müllerian duct in the marsupials. Buchanan and Fraser have shown in *Trichosurus* that the Wolffian duct has already opened into the cloaca before the primordium of the Müllerian duct is first recognizable. Later the Müllerian duct, following the precise course already established by the Wolffian duct, lying at first on the outside but gradually moving its relative position until in its posterior section the Müllerian duct lies medial to the Wolffian duct in close association with it.
>
> The ureters arise as outgrowths from the Wolffian ducts and in the case of the 'placental' mammals (Eutheria) take a lateral course from their point of origin while in the marsupials (Metatheria) they take up a position medial to the Wolffian duct. Thus, the Müllerian ducts, in the Eutheria, take up a medial position side by side and ultimately coalesce in the middle line to form a single median vagina lying betwen the roots of the ureters, whereas in the Metatheria they remain as two separate tubes lateral to the ureters throughout life. In females each Wolffian duct degenerates and disappears except for a mere vestige which we believe persists in the Marsupialia, as a

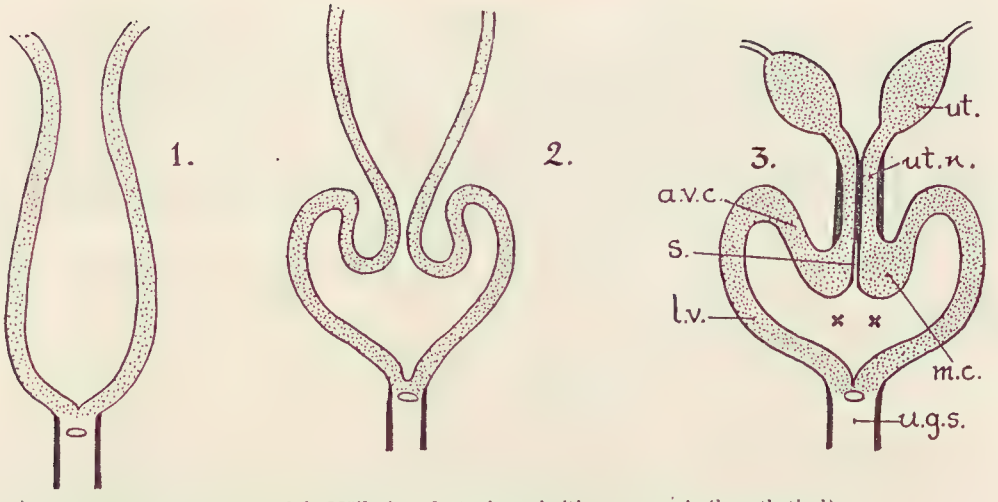

FIG. 1.—Arrangement of r. and l. Müllerian ducts in primitive mammal (hypothetical).
FIG. 2.—Embryonic arrangement of r. and l. Müllerian ducts in all marsupials.
FIG. 3.—Condition of the vaginal complex in the more primitive marsupials.
NOTE.—The two crosses indicate the level at which the two ureters enter the bladder.

a.v.c.—anterior vaginal canal
l.v.—lateral vagina
m.c.—median vaginal cul-de-sac
s.—septum between r. and l. culs-de-sac
u.g.s.—urogenital sinus
ut.—uterus
ut.n.—uterine neck

component of the posterior region of the lateral vagina in company with the Müllerian duct. In males the two Müllerian ducts usually disappear though vestiges may persist in some mammals.

The developing Müllerian ducts do not run caudally by the shortest route but follow the somewhat devious course already set by the Wolffian ducts, and are thus deflected medially until they almost meet, and then sweep outward and forward passing lateral to the ureters and then again in a caudal direction to reach the sinus.

This flexure of the Müllerian ducts (fig. 2) is characteristic of all Marsupials and the point at which the two ducts approximate most closely to each other marks the ultimate separation of each Müllerian duct into its two most important adult components, the uterus and the vagina.

Throughout the vertebrate series, with the exception of the viviparous mammals, the right and left Müllerian ducts remain distinct from each other throughout life. It may be assumed that this was also the case in the prototypal marsupials and many of the less specialized recent marsupials still retain this primitive condition (see fig. 3). However, in most marsupials the right and left Müllerian ducts communicate with each other immediately caudal to the uterine necks (figs. 4 and 5, *m.c.*). In the *Potoroidae* (Rat-Kangaroos) there is a further junction between right and left sides in the most anterior region of the vaginal complex where both anterior vaginal canals become enlarged and fuse to form a single chamber, the anterior vaginal expansion (fig. 6, *a.v.e.*).

The anterior part of the vaginal complex (anterior vaginal canal and its derivatives, including the anterior vaginal expansion) is concerned with the storage of spermatozoa received from the male during the period of oestrus. As will be seen later the lateral vaginae lose their original parturient function and become converted into spermathecae. The simplest modification is seen in the Macropodidae (fig. 5) in which the anterior portions of right and left vaginae become greatly distended during the oestrus period due to the presence of spermatozoa which have been received through the lateral vaginae. In the Potoroidae (fig. 6) the right and left enlargements (spermathecae) fuse to form the anterior vaginal expansion referred to above. This provision of a spermathecal system reaches its highest development in *Bettongia* in which the anterior vaginal expansion takes the form of a swollen anterior caecum which extends forward and lies immediately below the uteri.

This spermathecal caecum is homologous with the similar structures in *Perameles* (fig. 4, *caec.*) except that in the latter genus the right and left expansions remain separate and do not fuse, though the two separating walls lie close to each other in the middle line. Incidentally, it is worthy of note that *Perameles* is not a primitive and unspecialized marsupial as is sometimes claimed. Externally the feet show considerable specialization and the female urogenital system is specialized in the following respects:—

(1) The presence of a pair of vaginal caeca.
(2) The extreme anterior position of the openings of the ureters into the bladder.
(3) The extremely long lateral vaginae with a consequent long pseudovaginal gap.
(4) The short urogenital sinus.

The condition shown in fig. 3 may be regarded as typical of the marsupial vaginal complex and is found throughout the Didelphoidea, Caenolestoidea and the Dasyuroidea as well as in the least specialized members of the Phalangeroidea. However, occasionally it is found in these super-families that the septum (fig. 3, *s.*) between the right and left culs-de-sac breaks down, thus bringing about a junction between the right and left Müllerian ducts as described above.

The characteristic double kink of the vaginal system, shown in fig. 2, is found in the early developmental stages of all marsupials though it may be disguised in the adult condition of the more specialized type of vaginal complex (see figs. 4 and 6).

It is clear that this double kink must have made the act of parturition a very hazardous business for the prototypal marsupials (unless, as is not unlikely, the Müllerian ducts were still in the primitive phylogenetic condition shown in fig. 1). J. P. Hill has shown that this difficulty was overcome by the improvisation of a more direct passage for the purpose of parturition

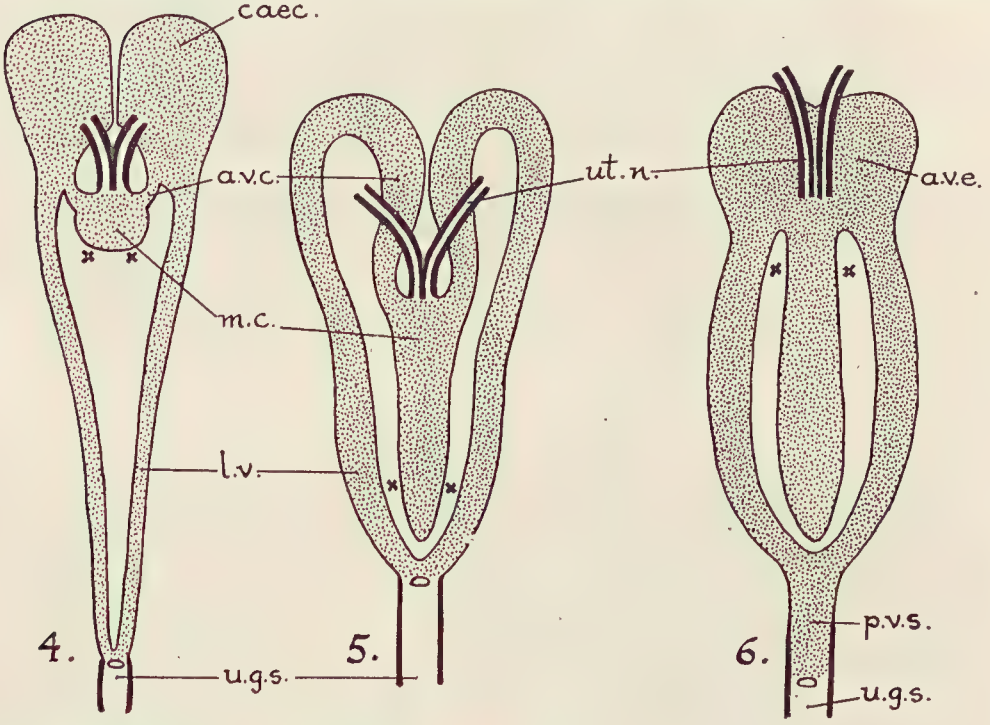

FIG. 4.—The vaginal system of *Perameles*.
FIG. 5.—The vaginal system of a Kangaroo (Macropodidae).
FIG. 6.—The vaginal system of *Potorous* (Potoroidae).

NOTE.—The uterine bodies are not shown.

a.v.e.—anterior vaginal expansion
caec.—vaginal caecum
p.v.s.—posterior vaginal sinus
(other letters as in figs. 1-3)

by way of a 'pseudovagina'. When the embryos pass from the uterus into the cul-de-sac the fluid pressure which has been set up is sufficient to force the embryo through the posterior wall of the cul-de-sac into a tract of loose connective tissue which extends caudally as far as the urogenital sinus. Probably this impetus also enables the embryos to force their way through the wall of the urogenital sinus. It may be assumed that at this crisis the epithelial walls of both culs-de-sac and sinus are subjected to hormonal action which assists the double 'break through'. In the more specialized marsupials the culs-de-sac are considerably enlarged in a caudal direction so as to reduce the pseudovaginal passage, and in extreme cases they reach the urogenital sinus (figs. 5 and 6). The climax to this extraordinary story of pseudovaginal parturition is reached in a few marsupials (some of the Macropodidae and *Tarsipes*) in which a permanent epithelial connexion is set up between the cul-de-sac and the sinus to form a permanent median vagina.

It is to be observed that this "median vagina" resembles the Eutherian vagina in three important respects.

(1) it is of Müllerian origin
(2) it is formed by the fusion of portions of the right and left Müllerian ducts
(3) it lies mesial to the ureters.

In other words, a structure has been produced in some of the more specialized Metatheria which resembles the highly efficient vagina of the Eutheria both in position and function, but which has been evolved in an entirely different way.

This is, *par excellence*, an example of convergence in which structures similar in function and in anatomical position have been produced independently

In this connexion it is necessary to point out that the '3-way vagina' so formed in a few specialized marsupials is not characteristic of the Marsupialia as a whole. Indeed the normal marsupial possesses short culs-de-sac and the presence of a functional 'median vagina' is the rare exception and not the rule. It is necessary to make this clear in order to correct the impression conveyed in some text books on this important point.

An examination is being made of embryological and adult material to determine the constitution of the posterior region of the lateral vagina about which there has been some difference of opinion. Our evidence seems to show that the lateral vagina consists of three parts

(*a*) the major portion (anterior) consisting of Müllerian duct only;
(*b*) this is followed caudally by a section which consists of both Müllerian and Wolffian elements lying side by side and both contributing to the epithelium which bounds the lumen in this region. The vestigial Wolffian duct is sometimes seen at the anterior end of this region as a short degenerate stump;
(*c*) a short posterior section formed from the sinus horn (sinus tissue).

19th November, 1951.

A meeting was held in the Society's Room. Professor S. W. Carey, Vice-President, took the chair at the beginning of the meeting.

This meeting was an important occasion as the Society welcomed its new President the Rt. Hon. Sir Ronald Cross, Bt., who had recently taken over the office of Governor of Tasmania. Professor Carey informed the meeting that the two Vice-Presidents and the Honorary Secretary waited on His Excellency on Tuesday, 28th August, to ask him whether he would agree, under Rule 11, to accept the office of President of the Society, and His Excellency acceded to this request. He therefore, had pleasure now in inviting His Excellency to take the chair as President of the Royal Society of Tasmania, and expressed the hope that members would have the pleasure of seeing our new President guiding the affairs of the Society on many occasions. His Excellency then took the chair.

The President then presented the Clive Lord Memorial Medal to Professor J. Burke, Professor of Fine Arts at the University of Melbourne, and asked him to deliver the Clive Lord Memorial Lecture entitled "The English Background of Colonial Architecture in Australia". This lecture was illustrated by lantern slides.

The following were elected members of the Society:—Mrs. F. Pryde, Miss L. I. King, Miss N. C. King, Dr. F. Ahamd, Mr. L. R. Butler, Mr. F. H. Long, Dr. K. Rodger.

The meeting then adjourned to the Zoological Room in the Museum where coffee was served.

Northern Branch

Annual Report

The Annual Meeting was held on the 30th March, 1951, Mr. J. E. Heritage presided, and the following office-bearers were elected:—

Chairman: Dr. C. Craig.
Vice-Chairman: Mr. J. E. Heritage.
Council: Messrs. G. C. McKinlay, W. Baulch, G. Crawford, W. Gellie, Rev. J. C. Jones.
Hon. Secretary and Treasurer: Miss I. Thomson.

In November, the Rev. J. C. Jones resigned and Mr. K. R. von Stieglitz was elected to the vacancy for the remainder of the term.

Meetings

During the year eight Council meetings and seven General meetings have been held. Historical Expeditions have been held to George Town and Clarendon.

Historical notes on these districts have been issued to members.

General Meetings were as follows:—

March 30th, 1951	Prof. S. W. Carey: "Industrial Power from Volcanoes".
May 5th, 1951	Mr. M. R. Banks: "Geology in the Community".
June 15th, 1951	Mr. J. B. Boniwell: "An Introduction to Geophysics".
July 13th, 1951	Messrs. J. E. Heritage, J. Curtis, W. F. Ellis, Dr. C. Craig: "The Tasmanian Aborigines".
August 31st, 1951	Mr. J. B. Thwaites: "Scenery Preservation in Tasmania".
October 16th, 1951	Prof. H. N. Barber: "The Experimental Control of Flowering".
November 30th, 1951	Dr. C. Craig: "The early History of Northern Van Diemen's Land with special reference to York Town, Launceston and George Town".

Membership

Membership of the Branch now stands at 132, showing an increase of 27 during the past year.

Donations

The Branch is indebted to many members who have helped throughout the year. Mr. K. R. Von Stieglitz has generously donated notice cards to the Society, Dr. C. Craig has presented the material he collected for his lecture " On the early settlements in the North of the Island " and Mrs. H. Stewart has given the manuscript material of the work of her late husband. Thanks are due to these and to all other donors.

The Branch offers its congratulations to Mr. K. R. von Stieglitz on being given an O.B.E., for his valuable work in the historical field.

To the Chairman, Vice-Chairman, Members of the Council and to the Press are thanks due for their continual help and co-operation in the work of the Society.

Meetings, 1951

30th March, 1951

The Annual Meeting of the Royal Society of Tasmania, Northern Branch, was held at the Museum, on Friday, the 30th March, at 8 p.m.

The Annual Report and Balance Sheet were adopted.

Mr. J. E. Heritage presided.

Under the rules the following Office-bearers were elected:—

Chairman: Dr. C. Craig.
Vice-Chairman: Mr. J. E. Heritage.
Council: Rev. J. C. Jones, Messrs. W. Baulch, G. C. McKinlay, G. H. Crawford, W. Gellie.
Hon. Secretary and Treasurer: Miss I. Thomson.

An illustrated lecture was given by Professor S. Warren Carey, Senior Vice-President of the Royal Society, on " Industrial Power from Volcanoes ".

He said that there was a moral responsibility on civilisation to harness never-ending sources of power, such as hydro, solar, wind and volcanoes, before using coal and petroleum reserves, which once used, could never be replaced.

Profesor Carey stressed that at the present rate of use there was only coal supply for 1000 years and reserve for 10 years, Volcanic power could be harnessed and the world had such a colossal reserve that there was no chance of exhaustion.

The Speaker discussed developments of this power in Italy, New Zealand and Japan, and explained the methods used.

5th May, 1951

A meeting was held at the Museum, Dr. C. Craig presiding.

Mr. M. R. Banks, lecturer in Geology at the University of Tasmania, spoke on " Geology in the Community ".

Mr. Banks said that Man, through industry, is dependent on rocks and the minerals they contain to maintain his standard of civilisation. Geologists here are already, owing to the threat of reduced exports from America,

intensifying their search for the raw materials of sulphuric acid, a basic requirement for industrial purposes.

The Persian oil crisis accentuates the need for Australia to find and develop oil fields close at hand. In this need the geologist is in the forefront of investigations.

Mr. Banks said that even in building a city the geologist can advise on the best site, best local building material and precautions against instability of the underlying rocks.

15th June, 1951

A meeting was held at the Museum, presided over by Mr. J. E. Heritage.

Mr. J. B. Boniwell was the Speaker. He took as his subject "An Introduction to Geophysics".

Mr. Boniwell explained the meaning and use of Geophysics in many undertakings, especially those concerned with oil and water prospecting today. He described instruments used in these processes and the methods employed, illustrating his talk with slides.

13th July, 1951

A meeting was held at the Museum, Dr. C. Craig presiding.

The lecture took the form of a symposium of "The Tasmanian Aborigines".

Speakers were:—

Mr. J. E. Heritage: who after a general review of the problem discussed past and current theory of the origin of the group.

Mr. W. F. Ellis: who discussed the nature and distribution of the Archaeological deposits left by the Tasmanians.

Mr. J. Curtis: who described their implements and weapons and their uses.

Dr. C. Craig: who, under the heading "Were the Tasmanians a successful race?" concluded the series with a review of their culture and its relation to environment.

31st August, 1951

A meeting was held at the Museum, Mr. F. Smithies presiding.

An illustrated lecture on "Scenery Preservation in Tasmania" was given by Mr. J. B. Thwaites, Acting Superintendent of Scenery Preservation Board.

Mr. Thwaites outlined the aims and work of the Board and showed coloured films of the Youth Hostels already set up, of historic buildings and of general Tasmanian scenery.

16th October, 1951

A meeting was held at the Museum, Dr. C. Craig presiding.

Professor H. N. Barber spoke on "The Experimental Control of Flowering".

Professor Barber opened his address by reviewing the research work at present being undertaken in his department at the University of Tasmania. He stated that it was hoped to have Rodway's "Flora of Tasmania" revised and in the hands of the Government Printer by 1955 or 1956. The Speaker then described, with the aid of slides, experiments illustrating various factors that bear upon the flowering of plants. He pointed out, how, within limits, the flowering of plants can be experimentally controlled.

30th November, 1951

A meeting was held at the Museum, the President of the Society, Sir Ronald Cross, presiding.

The Speaker, Dr. C. Craig, gave an address on "The early history of Northern Van Diemen's Land, with special reference to York Town, Launceston, and George Town".

Dr. Craig presented much original material connected with these early settlements and gave many previously unknown details of the founders and their ability and achievements.

The lecture was illustrated with slides of the settlements, maps and extracts of reports and correspondence.

Royal Society of Tasmania

Northern Branch

Statement of Assets and Expenditure for Year Ended 31st December, 1951.

ASSETS.	£	s.	d.
By Cash on Hand	91	11	5
Bank Interest	1	5	6
	£92	16	11

EXPENDITURE.	£	s.	d.
To Stamps and Postages	11	10	0
Travelling Expenses	8	18	0
General Expenses	10	9	9
Library	18	6	5
Stationery	1	2	3
Balance to Next Account	42	10	6
	£92	16	11

Audited and found correct, J. C. WILLIAMS.
1.1.52.

Obituary Notice

ARCHIBALD LAWRENCE MESTON, M.A. (1890-1951)

Archibald Lawrence Meston, elder son of the late Mr. and Mrs. Andrew Meston of Southern Rhodesia, was born at Launceston, Tasmania, on 5th June, 1890, and died at his home, Windsor Park, Glenorchy, on 21st December, 1951. His boyhood days were spent in Launceston and he received his early education at the Glen Dhu Primary School. In 1906 he joined the Education Department and entered the Teachers' Training College, where he qualified for matriculation. He had already displayed marked ability in the subjects of History and English Literature and was now in a position to continue the study of these subjects at the University.

He enrolled in the Faculty of Arts in 1909, but, like many other young teachers, soon discovered that the demands of his chosen vocation prevented his attending lectures as a full-time student. In 1911 he was appointed to the staff of the Battery Point State School and two years later was transferred to the West Coast, where he taught at Queenstown and Gormanston. In spite of his isolation from the University he continued his studies as an extra-mural student and completed with notable success not only the course for the Degree of Bachelor of Arts but also part of the Law course.

His distinguished academic record soon gained him a post in Secondary Education and he was appointed to the staff of the Hobart High School. In a very short time he was transferred to the Launceston High School and promoted to the position of Master of a Subject Department. It was while occupying this responsible position and still continuing his university studies as an extra-mural student, that he took the Degree of Master of Arts, obtaining first class honours in English. The examiners commended him for the merit of his work and the originality of thought which it displayed.

In 1929, A. L. Meston's ability was further recognized by his being appointed headmaster of the Devonport High School. Three years later he was placed in charge of the Launceston High School. Although occupied with the numerous duties associated with the position of headmaster of a large secondary school, he found time to write ' A Junior History of Australia '. The book was published by the Oxford University Press. It is intended for young scholars but is written in such an attractive style and tells the story of Australia in such a fascinating way, that it appeals to both young and old readers. He dedicated the book to ' M.J.M. and other little Australians', M.J.M. being the initials of his youngest daughter.

By now his reputation in the field of secondary education was well established and his many friends were highly pleased when he was invited by the Commonwealth Government to represent Australia at the Seventh International Conference on Public Education, which was held at Geneva in 1938. While abroad he also visited England and South Africa.

On returning to Tasmania he was appointed an Education Officer and at the time of his death held the responsible position of Education Officer for High Schools. For nearly twenty years he served on various committees connected with the Public Examinations and did much to widen and liberalize secondary education in this State. In 1944, when the Schools Board of Tasmania was constituted, he became one of its most active members. Much of the work connected with planning the new courses of study for which the Board was responsible was carried out by him or under his guidance. As a member of the Faculty of Arts for more than ten years, he kept in close touch with the University and always endeavoured to strengthen the link between the University and the schools. He had a large part in the plan which initiated the present scheme of university training for teachers.

However, A. L. Meston will be remembered not only for his work in the field of Secondary Education but also for his researches in Tasmanian history and anthropology. His historical studies included publications on the growth of self-government in Tasmania, the work of the Van Diemen's Land Company in land settlement, and work of the astronomer, Alfred Barrett Biggs. When examining old documents and maps dealing with various areas of the State, he was never satisfied until he had traversed the

same areas on foot and had been able to recognize the geographic features to which the documents and maps referred. There were few parts of Tasmania that he did not know intimately and nothing pleased him more than climbing some remote mountain or tramping through the virgin bush. His familiarity with the origin and history of place names was remarkable.

He possessed a first-hand knowledge of many Tasmanian animals and plants. The eucalypts were of special interest to him and he had planted many different species in the grounds of his home at Glenorchy. Any movement to establish sanctuaries for the protection and preservation of the native flora and fauna always received his support. In 1932 he was appointed chairman of the Board set up to control the Cradle Mountain Reserve.

His contributions to a knowledge of the culture of the Tasmanian aborigines are of the greatest importance and have attracted international attention. In 1931 he made a thorough study of the aboriginal rock-carvings on the Mersey Bluff near Devonport and was the first to publish a detailed and accurate description of them. In the following year he described a more elaborate series of carvings, which he had discovered on the West Coast of Tasmania near Mount Cameron West. Papers in which he discussed the form and probable significance of these carvings appeared in the journal of this Society for the years 1931 and 1932 and also in the British archaeological journal, 'Antiquity', published in June, 1934.

Questions concerning the origin of the aborigines and the route by which they came to Tasmania always interested him and he never tired of searching for evidence that might throw some light on these problems. With the help of fishermen operating off the north coast he had visited many of the smaller islands in Bass Strait, hoping to find some indication that the aborigines had reached Tasmania by way of these islands. In a well-reasoned paper read before the Northern Branch of this Society in August, 1936, he discussed the existing theories and presented his own views on 'The Problem of the Tasmanian Aborigine'.

In Tasmania there were few native camping sites and middens that he had not examined. In the course of his investigations he had built up an extensive and unique collection of aboriginal implements and artifacts. His home contained a valuable library, which revealed the breadth of his interests. Many rare works on the early history of Tasmania lined the walls of his study. He became a recognized authority in his chosen field of research and shortly before his death he was invited to write the section on the Tasmanian aborigines for the new edition of the Australian Encyclopaedia. In 1949 he was elected a Vice-President of the Anthropology Section at the Hobart meeting of the Australian and New Zealand Association for the Advancement of Science.

The objects of the Royal Society of Tasmania were furthered not only by the papers which A. L. Meston contributed to its journal but also by the active part which he took in the Society's work. He became a member in 1921 and was Chairman of the Northern Branch in 1936 and 1937. On moving to Hobart he served on the Council for ten years and was a Vice-President of the Society in 1942, 1943, 1949 and 1950. He was also a trustee of the Tasmanian Museum and a member of the Editorial Board of Historical Studies of Australia and New Zealand.

In all his work he enjoyed the sympathetic help and understanding of his wife and family. His home was a centre of hospitality and good-fellowship. Friendliness and a delight in the simple pleasures of life were keynotes in his character. Although in failing health during the last four years, he maintained a courageous spirit and refused to relinquish his work.

He has left as enduring memorials a record of unselfish service in the cause of Secondary Education in this State and notable contributions to the study of Tasmanian anthropology.

V.V.H.

L. G. SHEA, Government Printer, Tasmania.

PAPERS AND PROCEEDINGS

OF

The Royal Society of Tasmania

Volume 87

Edited by D. MARTIN

PUBLISHED BY THE SOCIETY

The Tasmanian Museum and Art Gallery, Hobart

1953.

Price: Twenty Shillings

The Royal Society of Tasmania

Volume 87

Patron:
Her Majesty the Queen.

President:
His Excellency Rt. Hon. Sir Ronald Cross, Bt.

Vice-Presidents:
J. W. C. Wyett, B.Sc., A.A.C.I., 1952.
W. H. Hudspeth, B.A., till April, 1952.
L. W. Miller, M.Agr.Sc., F.R.E.S., from May, 1952, 1953.

Council:
Professor H. N. Barber, M.A., Ph.D., 1952, 1953, 1954.
I. G. Anderson, F.R.S.A. (Lond.), 1952, 1953, 1954.
S. W. Carey, D.Sc., 1952, 1953.
C. Bisdee, 1952, 1953.
W. L. Crowther, D.S.O., M.B., F.R.A.C.P., 1952.
M. S. R. Sharland, 1952.

Hon. Secretary and Librarian:
Joseph Pearson, D.Sc. (Manchester), D.Sc. (Liverpool), F.R.S.E., F.L.S.

Assistant Hon. Secretary:
D. Martin, M.Sc.

Hon. Treasurer:
S. Angel.

Hon. Auditor:
A. M. Hewer.

Hon. Editors of the Papers and Proceedings:
Joseph Pearson and D. Martin.

Standing Committee:
W. L. Crowther, S. W. Carey, J. W. C. Wyett, J. Pearson, D. Martin.

Annual Report, 1952

The Annual Meeting was held in the Society's Room, Tasmanian Museum and Art Gallery, on the 4th March, 1952.

The president, His Excellency the Governor, presided.

The following Office-bearers were elected:—

Vice-President: Under the Society's Rules Professor S. W. Carey retired from the office of Vice-President, and Mr. W. H. Hudspeth was appointed in his place (retiring 1954).

Hon. Secretary and Librarian: Dr. Joseph Pearson.

Hon. Assistant Secretary: Mr. D. Martin.

Hon. Treasurer: Mr. S. Angel.

Hon. Auditor: Mr. A. M. Hewer.

Council: Under Rule 21 Mr. W. H. Hudspeth and Mr. F. C. Wolfhagen retired as members of the Council and Professor H. N. Barber and Mr. I. G. Anderson were elected in their place for a period of three years. Professor S. W. Carey was elected for two years in the place of the late Mr. A. L. Meston. Later in the year (May) Mr. L. W. Miller was elected a Vice-President in place of Mr. Hudspeth who died on 1st April, and Mr. C. Bisdee was elected to serve two years in the place of Mr. L. W. Miller.

The names of the full Council for 1952 are given on the previous page.

The Council made the following appointments at its first meeting:—

Assistant Librarian: Miss J. Robertson.

Standing Committee: Mr. J. W. C. Wyett, Professor S. W. Carey, Dr. W. L. Crowther, and the Hon. Secretary.

Board of Trustees of the Tasmanian Museum, and Board of Trustees of Botanical Gardens: The Society's representatives for 1952 were as follows:—

Board of Trustees, Tasmanian Museum: Professor T. Hytten and Professor A. Burn.

Board of Trustees, Botanical Gardens: Mr. S. Angel.

Northern Branch Representation on Council: During the year the Council discussed the desirability of having a closer liaison with the Northern Branch and it was resolved that the Council of the Northern Branch should be invited to appoint one of its number to attend the meetings of the Society's Council in Hobart, and to have the status of a member of Council. Mr. K. von Stieglitz, the present President of the Northern Branch was appointed to fill this office during the year 1952.

Meetings: Nine ordinary meetings and one special meeting were held during the year. At the conclusion of the November meeting a Conversazione was held at which approximately 250 people were present.

Refreshments: After considerable discussion in the Council an important innovation was made at the July meeting of the Society when supper was served after the meeting. In order to meet this special service it was found necessary to purchase crockery and a tea urn, which were obtained from the funds. This departure has proved most successful and it is proposed to make it a permanent feature in the Society's General Meetings.

Library: This year the periodicals continued to be revised. This involved an increase of 3,569 volumes in the Accession Book, which includes numbers of small booklets which had hitherto not been entered in the Accession Book and books and periodicals purchased or received by way of exchange from various institutions. The number of Institutions on the exchange list is now 271 and new exchanges have been arranged with the following institutions: Museum van Belgisch Congo; la Station Biologique de Roscoff, Hungarian Academy of Sciences; Accademia ligure di scienze e lettere; Institute di Entomologia della Universite degli Studi, Bologna; Sociedade Broteriana, Institut Botanique de l'Universite de Coimbra; Universidade de Lisbon. Faculdade de Ciencias; Estacion de Biologia Marina, Universidad de Chile; Universidade Central de Venezuela.

The Library now consists of 29,084 volumes.

Library Loans: For some years past an arrangement has been carried out with the Northern Branch of the Society by which certain periodicals from the Library are sent to Launceston on short loan. This practice which has been appreciated by the Northern members, has now been extended to the Science Library (Sandy Bay) of the University of Tasmania during the present year.

Library Lectures: The State Library Board has instituted a course of lectures on Library Technique under the guidance of Mr. F. Johnson and the State Librarian applied to the Council for permission to use the Society's room for these lectures which are held five days a week for the greater part of the year. The Council decided that they welcomed the opportunity of assisting this important move.

Changes in Staff: Miss Barbara Veale, who, though a member of the University Library Staff, had been seconded to the Society's Library to continue the work of cataloguing the Library, resigned in February, 1942, on the occasion of her marriage. The Assistant Librarian, Miss J. Robertson, succeeded Miss Veale and remained in the Society's Library to continue the compilation of the catalogue. Miss D. Bulman was appointed Assistant Librarian in February, 1952.

In December, 1952, the services of Miss Robertson were withdrawn from the Society's Library by the University authorities and thus our Library was left without a Cataloguer. Representations have been made to the Vice-Chancellor as to the serious position which has been created and it is hoped that the University will be able to continue the valuable work of cataloguing our Library for which they have been responsible for almost six years. The Council wishes to take this opportunity of expressing its gratitude to the University Council for having collaborated in this important work.

Membership: The Society consists of the following members:—

Honorary members		3
Corresponding members		2
Ordinary members—		
Class A	239	
Class B	155	
		394
Life members		29
Associate members		20
		448

During the year 33 names were removed from the List of Members owing to deaths, resignations, &c., and 37 new members were elected.

Honorary Member: At the meeting on 4th March, Dr. J. Pearson was elected an Honorary Member of the Society under Rule 45. The Chairman pointed out that Dr. Pearson was not only a scientist of great distinction who had made outstanding research contributions which have been published in the Proceedings of the Society, but, over a period of years, he had been the pivot of organized science in Tasmania and had contributed more to the honorary administration of science, including the administration of the Society, than any other individual.

Retirement of Dr. Pearson from the Directorship of the Tasmanian Museum: On 31st December, 1952, Dr. Pearson retired from the post of Director of the Tasmanian Museum and Art Gallery. The two posts, that of Honorary Secretary of the Society and the Directorship of the Museum are very closely bound together and it is difficult in practice to know where the duties of one office ends and the other commences.

The Council are deeply appreciative of the time and effort which Dr. Pearson has put into his duties as Secretary to the Society in addition to his obligations as Director of the Tasmanian Museum, which post he filled with such distinction and service.

Deaths: The Council regrets having to record the deaths of the following persons:—Mr. P. Anderson, Mr. K. Brownell, Mr. W. H. Hudspeth, Mr. W. E. Masters, Commander James Murray, R.N. (Rtd.), Mr. H. Oliver, Mrs. G. E. Perrin.

Mr. W. H. Hudspeth: The Society sustained a grievous loss when Mr. W. H. Hudspeth died on 1st April, 1952. Mr. Hudspeth first joined the Society in 1935 and served as a member of Council and on two occasions as Vice-President. He placed at the disposal of the Society his encyclopaedic knowledge of Tasmanian history. This knowledge was always willingly given to members of the Society and to historical students from the University and from the Mainland. In view of the fact that the Society's Library deals to a considerable extent with historical matters it would be difficult to fill the gap which has been caused by Mr. Hudspeth's death. It should be added that Mr. Hudspeth was also for some years Chairman of the Board of Trustees of the Tasmanian Museum and in

that capacity he was given a practical illustration of the intimate association which exists between the two Institutions. In his Will Mr. Hudspeth left £100 to the Society and also the following: 2 coloured lithographs by Elizabeth Hudspeth; the diaries and letter books of John Maule Hudspeth, Mr. Hudspeth's grandfather, and the diaries of his great grandfather, Thomas Hudspeth. In addition he left a most valuable collection of unpublished papers which, fortunately, will be placed at the disposal of the Society through the generosity of his son. A memorial notice dealing with Mr. Hudspeth's life and activities is appended to the present volume.

W. H. Hudspeth Memorial: A public meeting was held in the Society's Room on 26th January to launch an appeal for funds for the establishment of a Hudspeth Memorial. In response to this appeal a sum of £459 17s. 11d. was received and it was decided by the subscribers that the money should be used first to publish his paper " The Profile of a Pioneer " (500 copies) and that the balance of the money should be placed in the charge of the Council of the Royal Society of Tasmania to be used for the purchase of historical books for the Library and that each book should be inscribed to indicate that it formed part of the W. H. Hudspeth Memorial.

Mr. H. Oliver: Mr. H. Oliver joined the Society in 1924, and left £100 to the Society on his death.

Commander J. Murray: Mr. and Mrs. J. Murray have been faithful members of the Society for many years and Mrs. Murray gave £200 to the Tasmanian Museum in 1943 to be used for any Museum purpose which the Trustees decided upon.

Mr. W. E. Masters, LL.B.: Honorary Member: A full statement of his service to the Society was given in last year's annual report.

PAPERS AND PROCEEDINGS:

Finance: The steep rise in the cost of printing the Papers and Proceedings in the last two or three years has been a matter of great concern to the Council. The Society is entirely dependent upon the Government grant to maintain and publish its Journal each year. The Society's Journal has a long and honourable history and has appeared without a break since its first volume was published in 1849. The value of the journal is twofold. It provides a medium for the publication of scientific papers dealing with matter of special significance to Tasmania. It also enables the Society to enter into a reciprocal arrangement with learned Societies and institutions throughout the world by which a mutual exchange of publications has been established. In this way the Society's Library, now consisting of upwards of 26,000 volumes, has been built up in the course of over a century a Library which is not only used by members but also by Government Departments and members of the University. The Society's Library is a national institution and the Government has cause to regard with satisfaction the outcome of its generosity in giving financial aid to the Society and in this maintaining what is one of the finest Lbraries of its kind in Australia. Unfortunately in the present financial

year the Government has felt obliged to reduce its grant and the Council is confronted with a very serious situation which, if a solution is not found, might result in the size of the annual volume being reduced. The Government Grant for the 1952 volume (Vol. 86) was £400. The actual cost of printing the volume was £573. Thus the Council is faced with the problem of finding £173 to meet this charge. Fortunately this burden has been substantially reduced by a gift of £50 from the Zoological Department of the University of Tasmania towards the cost of printing Mr. Guiler's papers which appeared in the 1952 issue. In thanking the Government for the financial assistance which they have given to the Society for the printing of the Papers and Proceedings, special note should be made of the fact that a deficit of £24 19s. on the 1950 volume was paid by the Treasury.

Numbering the Volumes of the Papers and Proceedings: The annual volume of the Papers and Proceedings issued by the Society has always been given the designation of the year for which it formed a record, but in point of fact the volume was not published until the following year. This practice gave rise to some confusion as it became necessary in referring to the volume to give two dates. In order to obviate this difficulty the Council has now decided to number the volumes consecutively, and after a careful examination of the records of the Society it was found that the 1951 volume which was published in 1952 was actually the 86th volume of the series. The 1951 volume, therefore, was given the number 86 and the present volume in which this account of the Society's proceedings are printed will be Volume 87. It is important for members and institutions receiving the volume as an exchange to note this fundamental change.

The Royal Society of Tasmania

Statement of Receipts and Payments for Year Ending 31st December, 1952.

General Fund.

Receipts.

		£	s.	d.
Balance from last account		74	15	5
Subscriptions:—				
£2 223 + £1 4s.	£447 4 0			
£1 10s. 148	222 0 0			
£1 1s. 5	5 5 0			
15s. 15	11 5 0			
		685	14	0
Sale of publications		51	16	3
Rentals, &c.		56	7	8
Refund for Biological Abstracts—University of Tasmania		142	12	3
Sale of cupboards		10	0	0
Refunds: Clive Lord Memorial Lecture:				
Expenses from C.L.M. Fund	£11 17 4			
Expenses Friends of Museum	19 0 0			
		30	17	4
Refund, half cost Conversazione 30th September, Friends of Museum		19	0	0
Transfer of money from Funds for Books:				
R. M. Johnston Fund	£6 8 2			
Morton Allport Fund	7 2 2			
A. H. Clarke Bequest	3 8 7			
Milligan Bequest	5 1 2			
A. N. Lewis (1951)	6 16 1			
		28	16	2
		£1,099	19	1

Payments.

	£	s.	d.
Salaries	233	12	5
Library	162	19	10
Stationery, printing and advertising	48	14	6
Expenses lectures	35	2	3
Postage and delivery charges Papers and Proceedings	23	18	6
Light and power	82	7	9
Insurance	27	7	6
Govt. Printer, balance of Papers and Proceedings, 1951	70	0	0
Transferred Life Membership Fund, Biol. Abs.	110	8	10
Transferred, Reserve Fund, sale publications 1951	12	14	11
Miscellaneous	13	2	0
Equipment	98	10	4
Northern Branch, share subscriptions 1951	73	18	0
Petty cash (balance in hand £3 1s. 2½d.)	87	17	3
Balance to next account	19	5	0
	£1,099	19	1

S. ANGEL, Hon. Treasurer.
A. M. HEWER, Hon. Auditor.

J. W. C. WYETT, Vice-President.
JOSEPH PEARSON, Hon. Secretary.

Royal Society Funds

Statement of Balances for Year Ended 31*st December,* 1952.

	£	s.	d.
Reserve Account	95	9	1
Life Membership Account	281	7	9
Clive Lord Memorial Fund (£200)	13	0	6
R. M. Johnston Memorial Fund (£232)	0	9	7
Morton Allport Memorial Fund (£200)	0	10	8
A. H. Clarke Bequest (£100)	0	1	8
A. N. Lewis Memorial Fund (£250)	30	14	1
Milligan Bequest (£150)	0	3	4

Abstracts of Proceedings

4th March, 1952

Annual Meeting

The Annual Meeting was held in the Society's Room, Tasmanian Museum. The President, His Excellency the Governor, presided.

The following Office-bearers were elected for 1952:—Mr. W. H. Hudspeth was elected Vice-President in the place of Professor S. W. Carey, who retired under Rule 12; Honorary Secretary, Dr. J. Pearson; Assistant Honorary Secretary, Mr. D. Martin; Honorary Treasurer, Mr. S. Angel; Honorary Auditor, Mr. A. M. Hewer.

The following were elected members of the Council: Professor S. W. Carey was elected for two years in the place of the late Mr. A. L. Meston. Professor H. N. Barber and Mr. I. G. Anderson for three years in the place of Mr. W. H. Hudspeth and Mr. F. C. Wolfhagen who retired under Rule 21.

The following were elected members of the Society:—Mr. O. W. Reid, Mr. W. L. Clennett, Mr. J. Curtis, Mr. L. G. Ferrall, Rev. W. H. Macfarlane, Mr. E. G. Record. Hon. Member, Dr. J. Pearson, D.Sc., F.R.S.E., F.L.S. On the recommendation of the Council Dr. J. Pearson had been nominated for Honorary Membership of the Society at the last meeting In supporting the nomination, Professor S. W. Carey, on behalf of the Council, had outlined the reasons for which this proposal was being made. He pointed out that Dr. Pearson was not only a scientist of great distinction who had made outstanding research contributions which have been published in the Papers and Proceedings of the Society, but, over a period of years, he had been the pivot of organized science in Tasmania and had contributed more to the honorary administration of science, including the administration of this Society, than any other individual.

Mr. K. B. Fenton delivered an illustrated lecture entitled "Scientific Work at Macquarie Island", of which the following is an abstract:—

> The primary aim of the station maintained at Macquarie Island by the Australian National Antarctic Research Organisation is the collection of scientific data in various fields. At present observations are being made in the fields of meteorology, geophysics (geomagnetism and seismology), cosmic rays, radiophysics (ionospheric soundings, radio noise observations), and auroral observations.

1st April, 1952

A special Meeting was held in the Society's Room to amend the following Rules of the Society. Professor S. W. Carey presided.

Rule 14.—The following addition to the end of Rule 14 was agreed to:—" In addition the Committee of the Northern Branch may delegate a member of that Committee to attend the Council Meetings of the Society. He shall have the right to vote on all matters brought before the Council and in all other respects shall have the same privileges as other members of the Council.".

Rule 21.—The following addition was agreed to:—Immediately after the word " Office-bearers " add " and the representative of the Northern Branch ".

Amendment to the Rule governing the award of the Royal Society Medal.

2nd paragraph, p. 18 of 1938 edition of Rules to be preceded by the following words: " The Medal shall remain at all times the property of the Society ".

3rd paragraph, p. 18 of 1938 edition of Rules to be deleted.

New addition to Schedule II of Rules:

" Arndell Neil Lewis Memorial Fund

Amount of Fund, £232 17s. 11d. (plus the proceeds of subsequent sales of ' Geology of the Hobart District '.

Established, 19th March, 1947.

Purpose of Fund: The interest arising from the investment of the Fund to be used for the purchase of geological and other scientific books for the Society's Library. Each book so purchased to have a special Book Plate showing that the book is part of the A. N. Lewis Memorial Library ".

The Special Meeting was followed by:

General Meeting

A meeting was held in the Society's Room. Professor S. W. Carey, Vice-President, presided.

The following were elected members of the Society:—Mrs. J. L. Carter, Mr. G. B. Everard, Mr. A. Chittleborough, Mrs. K. Thyne, Mr. P. J. Clifford, Mr. E. Newman, Dr. F. R. Stevens.

Dr. W. M. Curtis delivered an illustrated lecture entitled " The Tasmanian Flora and Related Problems ", of which the following is an abstract:—

In Tasmania as in each of the Australian States, work is in progress on the preparation of a new Flora which will be an up-to-date record of the States' flowering plants. It seems relevant therefore to consider two questions, firstly why Floras are written, and secondly what are the features of special interest in the study of Tasmanian plants.

Modern Floras have a history which in Europe can be traced to the scientific school of Athens and to the manuscripts of Aristotle and Theophrastus. Through the succeeding centuries botanical knowledge became increasingly important to medical men as plants were collected to provide drugs. Manuscript works called herbals were prepared to aid the identification of plants. Until the fifteenth century, the time of invention of printing by movable type, such herbals were copied by hand, usually with steady deterioration in the illustrations. Not long after the manuscript herbals were put into print a new kind of herbal appeared: in Germany, Belgium and England there was an awakening of interest in native plants and a search for those with healing properties. One of the most famous is Gerard's Herbal which may still be consulted and which contains a strange mingling of fact and folklore. A modern Flora aims at providing a complete list of the plants of a particular area; it is based on the work of the pioneer botanical explorers and on the researches of the systematists, stimulated by the work of Linnaeus in the eighteenth Century. Today, in the identification of plants, botanists utilize data from contemporary work in the fields of physiology, biochemistry, anatomy, embryology, cytology, genetics and ecology.

The Tasmanian flora includes very few plants that are either edible or of value to medicine, but it is of considerable scientific interest. The distribution of plants of our mountain plateaux presents a problem to be worked out by collaboration between botanists and geologists, for a number of species found in this State are identical with or closely related to plants in the now widely separated land masses of New Zealand, Fuegia and Hawaii.

6th May, 1952

A meeting was held in the Society's Room. Mr. J. W. C. Wyett, Vice-President, presided.

The Chairman referred to the death of Mr. W. H. Hudspeth and Mr. L. W. Miller voiced the Society's appreciation of Mr. Hudspeth's services. (See Obituary, page xxi.).

The following elections then took place: Mr. L. W. Miller appointed Vice-President for two years in the place of the late Mr. W. H. Hudspeth; Mr. C. Bisdee appointed a member of Council for two years in place of Mr. L. W. Miller.

The following were elected members of the Society: Miss A. Wild, Mrs. M. L. O'Connor, Mr. W. R. Tucker, Mr. D. F. Wild.

Dr. J. B. Polya delivered a lecture entitled " The attack on Modern Chemistry by the Soviet Union ", of which the following is an abstract:—

Some of the most significant advances of modern chemistry have been made possible through the quantum mechanical interpretation of chemical bonds. Although a purely mathematical treatment is impossible at present, some rational approximations, notably the resonance theory, have been of great value to chemists. The resonance theory and, to a somewhat lesser extent, the related molecular orbital theory have been condemned in Soviet Russia. This condemnation and the resulting censure and recantation of well-known Soviet scientists took the same form as Lysenko's campaign against the geneticists.

A survey of the historical development of the main concepts of chemical bonding shows that the Soviet authorities are wrong in maintaining that the current ideas on bonding, held by the majority of leading Western and Soviet scientists, have not been developed as a capitalist, imperialist, nationalist, &c., device to belittle and harm the Soviet State and Russian scientists like Butlerov and Markovnikov.

The reasons behind the Soviet attack on modern chemical theories and the mode of this attack are not scientific. The real reasons may be connected with attempts to turn scientists from fundamental to immediately applicable research, hostility to intellectuals and to intellectual work beyond the reach even of the majority of trained scientists.

Details of the Soviet attack on modern chemical theories (mainly in the form of quotations) will be found in several 1952 issues of Nature and Journal of Chemical Education. Those who are still fortunate enough to enjoy a certain measure of scientific freedom should jealously guard this right.

3rd June, 1952

A meeting was held in the Royal Society's Room. Mr. J. W. C. Wyett, Vice-President, presided.

The following were elected members of the Society:—Mrs. N. M. Tooley, Mr. A. G. Mackinnon, Mr. D. J. McCulloch, Mr. J. R. Rex, Mr. F. J. White.

It was announced that a Public Meeting would be held in the Royal Society's Room on 26th June to discuss the question of a Memorial to the late Wilfrid Hugh Hudspeth.

Mr. W. N. Oates delivered a lecture entitled "Democracy, Swiss Pattern", of which the following is an abstract:—

The Swiss pattern of democracy has significance for international as well as national communities. The phrase "unity in diversity" gives a clue to this pattern. Elements of diversity are geographical (mountain, valley and plain), occupational (43 per cent industrial, 20 per cent agricultural), Linguistic (four official languages), religious (57 per cent Protestant, 41 per cent Catholic).

The Federal Constitution promotes unity. The Swiss citizen is a member of three communities—first of the Commune where he was born, then of the Canton and finally of the Confederation itself. He feels a strong sense of personal responsibility and personal participation as a democratic citizen. There can still be found examples of what might be called 'pure' democracy—the Landsgemeinden—where each citizen exercises in person his legislative power, but in most cantons a 'mixed' democracy form is in use which reserves for the citizen the rights of referendum and of initiative of legislation.

By its policy of neutrality, Switzerland has been a stabilising element in international affairs. As far back as 1815 Swiss neutrality was recognised by the Great Powers of Europe as being in the interests not only of Switzerland but of the policy and peace of Europe. The Swiss Constitution provides for mediation in the event of disputes and open conflict—certain cantons were admitted to membership on the express condition that they remained neutral in all inter-cantonal disputes and active as mediators. This idea could well be applied in an international context. Switzerland has become a symbol of the possible form which the union of peoples may one day take.

"Switzerland will have the last word in history" (Victor Hugo).

4th July, 1952

A meeting was held in the Society's Room. Mr. H. Allport presided.

The following were elected members of the Society:—Mr. D. Steane, Miss L. I. Slade, Mrs. I. V. Smith.

Mr. S. Angel (Hon. Treasurer, W. H. Hudspeth Memorial Fund) reported that a meeting had been held on 26th June and it had been decided to issue an appeal for subscriptions to a W. H. Hudspeth Memorial Fund.

Dr. C. Craig delivered an illustrated lecture entitled "The Five Attempts at Early Settlement at Port Dalrymple before 1827", of which the following is an abstract:—

The Principal settlement at Port Dalrymple was placed first of all at Outer Cove, then at York town, later at Launceston, then again at Outer Cove, now called Georgetown, and finally at Launceston. The purpose of this paper is to discuss the reasons for each change.

The first expedition entered Port Dalrymple on November 4th, 1804. The landing at Outer Cove was accidental and was due to the Buffalo running aground during the night. Everything was unloaded and taken to the nearby Outer Cove. Paterson was dissatisfied with Outer Cove. He considered that the surrounding land was not good and that the water supply would not last for the summer. During December he explored the river in the Lady Nelson. As a result he recommended to Governor King that the settlers should be placed on the rich ground at the head of the river in the valley of the North Esk, but that the principal settlement, to be called York town, should be at the head of Western Arm. His selection of York town was probably due to the instructions given him that he was to protect colonial vessels in Bass Strait. He would therefore wish to be as near the mouth of the river as possible. The only constant supply of water near the mouth of the river was at York town. He may also have taken into account that a settlement at York town could not be bombarded by a French warship.

Governor King accepted the suggestion as to York town, but considered that, for security's sake, the settlers should be in the neighbourhood of the principal settlement and not elsewhere. Paterson's first letter from York town is dated April 5th, 1805.

The main cause which led to the final abandonment of York town was the arrival from Calcutta of the herd of over six hundred cows (more than two hundred had died on the voyage). The cattle were landed at Outer Cove, but the death rate was tremendous. They were brought across the river to York town, but they still continued to die. In desperation Paterson finally decided to move them up the river to the " Ground adjoining the Cataract ". This move was completed by the beginning of 1806. In the meanwhile, an attempt at growing grain near York town had failed. This attempt was resumed at the North Esk and the first sod was turned either late in 1805 or early in 1806. In March 1806 Paterson wrote to King that he intended to move his headquarters to " The Cataract ". That he did not do so was probably, to a great extent, due to the force of habit. Substantial buildings had been erected at York town. A firm daily routine had been formed. To Paterson at all events, it is obvious that life there had become very pleasant. Although Paterson was a soldier, the great passion of his life was natural science. It might be said that he was a typical Royal Society man. By every mail he sent to his various friends who included Sir Joseph Banks, gifts of plants, seeds, specimens of ore, skins of animals, &c. Accompanying them went enthusiastic letters discussing his scientific investigations. He was, above all, a botanist. At York town he had formed a garden, the remains of which may still be seen. He therefore had strong personal reasons for remaining at York town. That, in the end, he did shift was due to a peremptory order from Bligh, who was now Governor in Chief; " Port Dalrymple is only to be one settlement, and not two ". Bligh's letter was dated 27th September, 1807. It is not known when Paterson obeyed Bligh's order as from then on he headed his letters " Port Dalrymple ". The heading " Launceston " appears first on 29th September, 1808 after Bligh had been deposed. This is the first occasion on which the name was used.

So far it may be said that the forces behind the moving of the principal settlement were those of nature. The removal back to Outer Cove was due to the force of a particular kind of personality—that of Macquarie who succeeded Bligh. If Paterson's great passion was natural science, Macquarie's great passion was the planning and building of cities. His temperament was that of a Roman emperor and his planning was always farseeing and on a large scale. It was he who really planned what was to be the great city of Sydney. It was his hand that first set Hobart on the way to being the jewel of the South. Both these cities were magnificently situated on the banks of great sheets of water. When Macquarie arrived in Launceston on December 8th, 1811, he was delighted as he crossed the brow of what is now Windmill Hill but was later disappointed. Accordingly he spent four days in the Lady Nelson exploring the river in the reverse direction to Paterson. The River Tamar is everywhere lovely, but it is only as it widens towards its mouth that it attains anything like majesty. Here, at Outer Cove, Macquarie decided to found the new city, to which he gave the royal name of Georgetown. Its main square was to be named Regent Square, and the small rivulet was called York River. The main street was Macquarie Street. It is worthy of note that there is a Macquarie Street at Hobart, a Macquarie Street at York town where Macquarie spent only a few hours and which had already been abandoned, a Macquarie Street at Georgetown, but no Macquarie Street at Launceston. Georgetown having been formed Macquarie sailed back to Sydney.

Macquarie found the greatest difficulty in getting his orders in regard to Georgetown carried out. Launceston was the natural centre of the settlement. It was surrounded by rich country and no one wished to move to the barren Outer Cove. It was only after years of cajoling and ordering that Georgetown finally became the principal settlement in 1819. Georgetown was never a success. What the settlers wanted was a shopping and marketing area. Launceston alone could fill this want. Georgetown moreover was not necessary

for shipping as it was found that ships could quite easily sail to the head of the river. There were few settlers near Georgetown and most of the supplies had to be laboriously rowed down from Launceston. Commissioner Bigge, after his visit in 1819 urged Macquarie to abandon Georgetown. Macquarie refused however, and after his own visit in 1821, he attempted to save the situation by urging Sorell to locate small farms for ticket of leave men in " Cimitiere Valley " near Georgetown, to establish a Government Farm, and to make the road from Launceston safer by erecting a guard house at " Mount Macquarie ". All this was of no avail however. Sorell, himself, both during and after his period of governorship, strongly urged the removal of headquarters from Georgetown, and finally, in 1826, Launceston again became the principal settlement.

Within recent years the foundation of the aluminium industry at the deep water port of Bell Bay has again made Georgetown important.

At the conclusion of the meeting Supper was served. The Chairman reported that the Council had decided to introduce this innovation at General Meetings in the future.

8th August, 1952

A meeting was held in the Society's Room. Mr. L. W. Miller, Vice-President, presided.

Mrs. G. B. Waters was elected a member of the Society.

Mr. M. Banks delivered an illustrated lecture entitled " The Architecture of Caves ", of which the following is an abstract:—

Four stages, at least, usually occur in the history of a cave containing " formations ". During the phreatic stage, solution takes place below the water-table and flow of water is very slow. The caverns themselves are formed at this stage. The second, clay-filling, stage follows and during this the caverns become filled with a pure clay which lacks bedding. After this stage the regional level of the water table seems to drop and swiftly flowing streams erode the clay and limestone and commonly deposit gravels. The last stage is that of deposition when stalagmites and stalactites are produced by the evaporation of water rich in calcium bicarbonate. Many other types of " formation " are produced during this last stage. Evidence of all four stages is found at Hastings and Mole Creek but caves in the Junee area do not seem to have reached the last stage.

2nd September, 1952

A meeting was held in the Society's Room. Mr. J. W. C. Wyett, Vice-President, presided.

The following were elected members of the Society:—Mr. L. G. Crawford, Mr. J. Feldmann, Mr. G. G. Haward, Mr. J. Swami Nath, Mr. D. P. D. Mahoney, Mr. R. C. Wilson, Mrs. J. Reader, Dr. M. W. Fletcher, Mr. R. L. J. Thomson, Mr. S. J. Walkden, Mrs. J. M. Fletcher.

The following exhibits were shown: 2 Lithographs by Elizabeth Hudspeth, *circa* 1851, one depicting a view on the Derwent and the other Ben Lomond, bequeathed to the Society by the late Mr. W. H. Hudspeth.

Professor S. Mangham, M.A. (Formerly Professor of Botany, University College, Southampton) delivered an illustrated Lecture entitled " Some Aims and Methods of Biological Studies in the Field ".

30th September, 1952

A meeting was held in the Society's Room. The President, His Excellency the Governor, presided.

The following were elected members of the Society:—Miss D. M. Ingram, Miss V. L. Buck, Mr. T. I. Ramsay.

Vice-Admiral, Sir Guy Wyatt, K.B.E., C.B., delivered a lecture entitled "The Hydrographical Work of the Royal Navy", which was illustrated by a documentary film. The following is an abstract of the lecture:—

> The Hydrography Department of the Royal Navy was formed in 1795. At the beginning of the First World War every maritime nation, except France, was using British Admiralty charts. During the last war the Department supplied 30,727,000 charts to Allied merchant ships. A chart is almost an entity, from the moment it is conceived it is subject to correction. New information comes in regarding aids to navigation, changes in shoals and so on, so that it is nothing uncommon for a chart plate already in the printing machine to have to come out for some latest addition. Every chart from the moment it is put in hand has a history kept in a special book in which the authority for everything that is placed on or removed from that chart is recorded. Once a chart is issued to the user it is kept corrected by Notices to Mariners which are issued to all H.M. Ships and Chart Depots and given gratis to all Chart Agents, Harbour Authorities and some Shipping Companies. In many British waters, including Tasmania, some of the charts in use were made 80 or 100 years ago. They are obsolete and badly need correcting.

The meeting then adjourned to the Zoological Room, Tasmanian Museum, where supper was served to approximately 250 guests.

4th November, 1952

A meeting was held in the Society's Room. Mr. L. W. Miller, Vice-President, presided.

The following were elected members of the Society:—Dr. Franklin Fay, Dr. F. R. Tyson.

Dr. Crowther reported that the W. H. Hudspeth Memorial Fund had a balance in hand of £425 2s. 5d. The fund would soon be closed and a meeting of subscribers called to decide what form the Memorial would take.

By the courtesy of the A.B.C. the following recorded talks of the late Mr. W. H. Hudspeth were reproduced:—(1) Hobart in the Nineties; (2) Mathinna; (3) Entally; (4) Nooks and Corners of Old Hobart—Government Cottage, Queenborough Cemetery, Princes Park. Between each item Dr. Crowther gave appropriate commentaries and the broadcasts in Mr. Hudspeth's familiar voice gave much pleasure to an audience of about 100.

The following exhibits were placed on the table for inspection:—2 specimens of the short headed lamprey (*Mordacia morda*), by Mr. A. M. Olsen of the C.S.I.R.O. Fisheries Division; (a) Warrant and Seal of Coroner William Lyttleton dated 1830, signed by Governor Geo. Arthur, (b) Transportation medals and picture of Governor Davey's proclamation 1816 for the natives—both exhibited by Mr. G. T. Triffitt.

Northern Branch

Annual Report for 1952

The annual meeting of the Royal Society of Tasmania, Northern Branch, was held at the Museum on the 7th March, 1952.

Dr. C. Craig presided and under the rules the following office-bearers were elected:—

Chairman: Mr. K. R. von Stieglitz.
Vice-Chairman: Mr. G. C. McKinlay.
Council: Dr. C. Craig, Mr. J. E. Heritage, Mr. W. Gellie, Mr. G. H. Crawford, Mr. R. Smith.
Hon. Secretary and Treasurer: Miss I. Thomson.

Meetings: During the year seven Council Meetings were held and nine General Meetings. Historical Expeditions were also held.

Membership: During 1952, twenty-four nominations for membership were received. We record with regret the deaths of two of our members, Mrs. G. E. Perrin and Mr. P. Anderson.

The Late W. H. Hudspeth: Members in the North regretted the passing of Mr. W. H. Hudspeth and have contributed generously to his Memorial Fund.

Books: The Library has been increased by the addition of approximately ten books.

Donations: Among donations gratefully acknowledged are:

Mr. G. Sidebottom—old newspapers.
Mr. W. Archer—old newspapers.
Rev. R. M. Rupp—orchid collection.
Mr. J. Hudspeth—collection of historical slides.

State Representation: The Branch is gratified that it has been given representation on the State Council.

Sesquicentenary Celebrations: The Branch has already made arrangements for the celebration of the State's Sesquicentenary. Plans for the proposed memorial to Lieut-Governor William Paterson at York town have been prepared by Mr. Gordon Willing and have been accepted by the State Sesquicentenary Committee.

It it also proposed that a memorial should be erected to William Collins who discovered the site of Launceston.

It has been decided that the erection of a plaque to mark the site of the building of the " Rebecca " which took John Batman to Victoria should be included in these celebrations.

During the time of the Centenary it is hoped to hold a series of public lectures dealing with the early history of the State.

Thanks are due to the Chairman, Members of the Council, and all who have helped and co-operated in the work of the Branch during the year.

Meetings, 1952

The Annual Meeting of the Royal Society of Tasmania, Northern Branch, was held at the Museum on Friday, the 7th March, 1952, at 8 p.m.

The Annual Report and Balance Sheet were adopted.

Dr. C. Craig presided.

Under the rules the following Office-bearers were elected:—

Chairman: Mr. K. R. von Steiglitz.
Vice-Chairman: Mr. G. C. McKinlay
Council: Dr. C. Craig, Mr. J. E. Heritage, Mr. G. H. Crawford, Mr. W. Gellie, Mr. R. Smith.
Hon. Secretary and Treasurer: Miss I. Thomson.

A Lecture on the port of Launceston was given by the Master Warden, Mr. W. Hart.

He surveyed the early history of the port when it was administered by the Colonial Office through a Port Officer at Georgetown and traced the history of the Marine Board, which was formed in 1858. Future developments and extensions as planned by the Board were discussed by the Speaker.

4th April, 1952.

A meeting was held at the Museum, Mr. K. R. von Stieglitz presiding.

Professor S. Warren Carey, of the University of Tasmania, gave a lecture on " The Geology of the Launceston District ".

Professor Carey outlined the development of the Launceston district from Pre-Cambrian times to the present day, with particular emphasis on the evolution of our present topography from the early Tertiary peneplain.

16th May, 1952

A meeting was held at the Museum, Mr. K. R. von Stieglitz presiding.

Mr. W. Baulch was the speaker. He gave the R. C. Gunn Memorial Lecture.

Mr. Baulch took as his subject—" A Tasmanian Botanist—Ronald Campbell Gunn " (1808-1881).

He outlined R. C. Gunn's career in Tasmania, stressing the contribution he made to Tasmanian Botany. R. C. Gunn, he said is better known to overseas scientists than to local people, although except for a few brief periods he had spent all his life in the north of the Island. He held a series of official positions and also managed Formosa Estate. During this period he collected extensively for the Hookers in England, and over 40 species of plants and several animals were named after him.

After an undistinguished period in Parliament, Gunn retired from public life to his home, " Newstead House ", and, what is not generally recognised, was the mainstay of the Northern Branch of the Tasmanian Society, until it was absorbed by the Royal Society. His extensive collection of plants was acquired by the Royal Society, and later transferred to the National Herbarium, Sydney.

11th June, 1952

A meeting was held at the Museum, Mr. K. R. von Steiglitz presiding.

Mr. Edmund Gill, of the National Museum of Victoria, was the speaker. He took as his subject " The Aborigines and the Ice Age."

Mr. Gill discussed various aspects of the field survey he had made recently in conjunction with the University of Tasmania, which included accurately locating and recording the site at Mowbray Swamp from which the fossil marsupial remains were obtained; locating and surveying ancient coast-lines revealed in aerial photographs; and a trial excavation in an aboriginal midden at Rocky Cape, which produced considerable fish remains, and a delicately pointed bone implement.

After discussing the significance of these discoveries, Mr. Gill briefly surveyed the present evidence relating to the antiquity of the Tasmanian and Australian aborigines.

11th July, 1952

A meeting was held at the Museum, Mr. K. R. von Steiglitz presiding. Mr. H. J. King was the speaker.

He gave a short review of the development of colour photography, and showed examples of early equipment. Mr. King then showed colour slides, depicting Tasmanian homes and countryside, concluding with an exquisite period group of an imaginary scene of a hundred years ago.

8th August, 1952

A meeting was held at the Museum. Mr. G. C. McKinlay presided. Mr. K. R. von Stieglitz gave a lecture on " The History of Circular Head ".

He outlined the work of early navigators, Bass and Flinders, Robbins, Kelly and Hardwicke, and the work of the early surveyors for the V.D.L. Co., Goldie and Fossey, Adeu, Jorgenson, Wedge and Hellyer, and discussed the original holdings and work of the Company itself in the North-West of the Island.

26th September, 1952

A meeting was held at the Museum, Mr. K. R. von Stieglitz presiding. Mr. V. J. Bahr, Deputy Director of Meteorological Bureau, Hobart, was the speaker. He took as his subject " The Importance of Reports from Sub-Antarctic Stations and from Shipping in forecasting in the Tasmanian Region ".

Mr. Bahr gave an outline of the development of forecasting, of the work of early meteorologists such as Lockyer, Russell and Epworth. He explained the methods used and gave an account of the location stations in Antarctica.

24th October, 1952

A meeting was held at the Museum, Mr. K. R. Stieglitz presiding. Mr. Roy Smith was the speaker. He took as his subject " Highway Rambles in Tasmania, with some Excursions into Architecture ".

Mr. Smith gave a brief outline of the main developments in architecture, and showed a collection of coloured transparencies of historical homes and buildings in Tasmania.

21st November, 1952

A meeting was held at the Museum, Mr. K. R. von Stieglitz presiding. Mr. E. D. Gill, of the National Museum of Victoria, showed a coloured film, illustrating geological time in Victoria and Tasmania.

6th February, 1953

A meeting was held at the Museum, Mr. K. R. von Stieglitz presiding. The speaker, Mr. Justice J. A. Ferguson, spoke on "Australian History and Bibliography".

He explained the technique of discrimination employed in the gathering together of bibliography, the problems confronting the bibliographer and the use of such publications.

At many of these meetings special displays were arranged.

Expeditions

Expeditions were held as follows:—

8th March, 1952	"Patterdale", Deddington, the home of John Glover.
29th March, 1952	"Trafalgar", the oldest home in the Evandale district, built by Andrew Barclay.
	"Pleasant Banks", the home of David Gibson.
5th April, 1952	Geological expedition of the Launceston district led by Professor S. Warren Carey.
27th April, 1952	"Quamby", the home of Sir Richard Dry.
27th September, 1952	"Richmond Hill", Cressy, the headquarters of the Van Diemen's Land Establishment.
25th October, 1952	"Panshanger", The home of Joseph Archer.
23rd November, 1952	Five Mile Bluff, North Coast, Tasmania.
1st February, 1953	"Bona Vista", the home of Simeon Lord.
15th February, 1953	Supply Creek, discovered by William Collins, 1804.
28th March, 1953	"Kingston", the home of John Batman, the founder of Victoria.

Historical notes relating to these expeditions have been issued to members.

Royal Society of Tasmania

(Northern Branch)

Statement of Assets and Expenditure for Year Ended 31*st December*, 1952.

Assets	£	s.	d.
Cash in hand 1/1/52	42	10	6
Subscriptions	73	18	0
Interest	1	12	0
	£118	0	6

Expenditure	£	s.	d.
Stamps and postages	24	17	6
Library	15	15	4
Printing	0	6	0
Travelling expenses	14	5	0
Sundry expenses	2	1	3
Balance to next Account	60	15	5
	£118	0	6

Audited and found correct,

J. C. Williams,
1st April, 1953.

Obituary Notice

Wilfrid Hugh Hudspeth

Wilfrid Hugh Hudspeth, Vice-President of the Royal Society of Tasmania, who died suddenly on April 1st, 1952, had been a member since 1935 and for most of that period a member of its Council. He had served too for a number of years, as one of the Society's nominees on the Board of Trustees of the Tasmanian Museum and as its wise and impartial Chairman during several difficult periods. Hudspeth was the fourth son of the Rev. Canon F. H. Hudspeth and Lucy Mills *nee* Cogle, both of whom came from the Jericho Valley—his father from " Bowsden ", the original grant to his family, and his mother from nearby " Huntworth ". From the Hutchins School he entered Trinity College, Melbourne, and graduated B.A. in 1895.

Having decided to adopt the law as his profession, Hudspeth, after serving his articles with Messrs. J. B. Walker and W. Wolfhagen, was admitted to the Supreme Court of Tasmania as Barrister and Solicitor, and was for a short period in the Solicitor-General's Department before joining the firm of Lewis and Gant, with which he remained until his retirement. This took place in 1935 and in the same year he joined the Royal Society of Tasmania. Hudspeth found a deep interest in its work and it was soon evident that his knowledge of Tasmania and its history was of unusual scope and accuracy. As a result, contributions, offered in the first place with his usual diffidence as lectures, came to be sought as fully documented papers for publication in the Proceedings of the Society. To be present at one of his addresses was a delight both for the interest of its matter and the manner of its presentation. He could be assured always of a full and appreciative audience. His help came to be more and more sought by those of similar interests in this and other States of the Commonwealth. In return he gave freely and unselfishly of his knowledge. An intimate personal relationship with the descendants of early colonists and his wide correspondence afforded him access to many early manuscripts and records in their possession. As a result the Library of the Royal Society has been enriched by the presentation of a number of such manuscripts or true copies of them typed by himself. In this manner for nearly two decades he worked at the State Archives, the Libraries and at home, preparing, typing and cataloguing. Indeed his retirement became, perhaps, the most interesting and exacting period of his life. It is good to know that much of his specialized knowledge will not be lost.

Apart from his published work he had with unusual care collated, prepared and filed historical data so that it would be available for consultation and the use of students. This very valuable collection has, by the

generosity of his son Mr. John Hudspeth, of Mt. Leslie, been placed in the Library of the Society. In his Will, with a monetary legacy, Mr. Hudspeth bequeathed to the Royal Society the diaries of his great-grandfather, Thomas Hudspeth, and the diaries and letterbook of John Maule Hudspeth, his grandfather.

To conclude, it would have embarrassed him beyond measure had mention been made of those delightful personal qualities so well-known to his friends. We may, however, deplore the loss of a wise historian and counsellor and one who, given the opportunity, would have been a great archivist and librarian.

The Royal Society of Tasmania

Papers and Proceedings Volume 87

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Pap. & Proc. Roy. Soc. Tasmania, Vol. 87 (15th August, 1953)

The Mineralogical Composition of some Tasmanian Clays

By

W. F. Cole and A. R. Carthew

Commonwealth Scientific and Industrial Research Organization,
Division of Building Research,
Australia

WITH TWO FIGURES

Abstract

An account is given of the mineralogical composition as determined by X-ray, differential thermal and chemical analyses, of some industrially important Tasmanian clays used in brick and agricultural pipe manufacture and as paper fillers. The clay deposits examined are mainly of Tertiary age and are both residual and sedimentary in origin. Kaolin is the dominant clay mineral in all samples with illite as a minor constituent in most; quartz is abundant in the brick and pipe clays. One sample from Surges Bay shows the presence of a mixed-layer mineral of montmorillonite and dioctahedral illite in both randomly stacked and ordered structures. An ordered structure of kaolinite and pyrophyllite or talc may occur also.

Introduction

In this paper no attempt has been made to examine systematically the clays of Tasmania but many samples, collected in the course of a reconnaissance survey of the clay industry of Australia as a whole by officers of this Division, have in recent months been subjected to examination by modern physical methods. The clays although of different origins are sufficiently alike to suggest that the results of their analysis could form the basis for future more detailed survey work of the island and hence it is considered of value to publish an account of their mineralogy as determined by X-ray, differential thermal analysis (D.T.A.) and chemical methods.

Samples

Clays have been examined from Dover and Surges Bay in the south, from Dunrobin in the centre and from South Mt. Cameron and St. Helens in the north-east of Tasmania (see locality map, Fig. I). The samples, taken mainly from operating pits of mining companies, represent most of the better known clay deposits of Tasmania. With the exception of three Permian clays from Dover the clays are all of Tertiary age and for the most part have arisen either directly or indirectly from the weathering of acid igneous rocks.

Clays from Dover

Most of the clays from Dover have been taken from the Granton Brick Company's works where a series of Tertiary lake deposits overlies Permian sediments weathering *in situ*. In all, seven samples have been examined; three of these having been collected by officers of the Division originally

for pilot plant examination and four supplied by G. Hale of the University of Tasmania. Sample 2 represents a clay which forms thin almost vertical " veins " through the main Permian clay body (sample 1) and in appearance is not unlike samples 3 and 4, whiting clays also of Permian age; samples 5, 6 and 7 represent the Tertiary clays of the area. The clays are used mainly for bricks by mixing equal proportions of 1 (Permian age) with the more plastic clays 5, 6 and 7 (Tertiary age) and for agricultural pipes by using the Tertiary clays alone.

Clays from Surges Bay

The clays from Surges Bay are derived from the weathering of a post-Jurassic syenite *in situ* and their distribution is complicated. The samples examined were obtained from the pit of Non-Metallic Minerals Ltd. where a weathered clay is mined for use as a paper filler. This clay shows interesting pseudomorphs after felspar.

Clays from South Mt. Cameron and St. Helens

In the Ringarooma valley sedimentary clay deposits are being worked by the Endurance Tin Mines N.L. at South Mt. Cameron. Here the profile exposed shows sandy gravel from 0 to 2 feet, brown and yellow clays with quartzitic boulders from 2 to 15 feet, white clay with patches stained light-brown by organic matter from 15 to 20 feet, with an underlying yellow clay. Sample 12 is representative of the white clay used as a paper filler, sample 13 of the stained white clay and sample 14 of the yellow clay.

In the Fern Tree River Valley west of St. Helens both sedimentary and residual clays are exposed in separate workings of the Goshen Tin Mines N.L. In one pit cut in the sedimentary clay 2 to 3 feet of sandy cover overlies 6 to 7 feet of clay and sample 15 is representative of the latter. Sample 16 was taken from a second pit cut through to the residual clay and is representative of clay formed from the weathering *in situ* of granite which underlies the sedimentary clays of the area.

Clays from Dunrobin Bridge

At Dunrobin Bridge near Ouse in central south Tasmania a bauxitic deposit is exposed in the valley of the Derwent River. Sample 17 is from the clay underlying the bauxite.

Experimental

X-ray Examination

X-ray photographs were always taken of the whole sample, of aggregates formed from a less than 2μ clay suspension prepared by conventional sedimentation methods, and of the aggregates after heating to between 500°C.—600°C. for several hours. Where necessary aggregates were also X-rayed after treatment with glycerol. In some instances the material remaining in suspension after centrifuging for several hours at 3000 r.p.m. was collected by flocculating with calcium chloride and examined by the X-ray method. In Sample 11 this finely divided material showed an almost pure separation of a mixed layer lattice mineral.

For most samples the X-ray examination was made with CuK_α radiation in a camera of small radius (3·00 cm.) which had been modified so

that spacings of the order of 20 A could be recorded. For one sample much larger cameras of radius 5·73 cm. and 11·46 cm. were used in order to establish the presence of a very high spacing.

Differential Thermal Analysis Examination

For a detailed description of the equipment used for differential thermal analysis examination in this laboratory see Carthew and Cole (1953), but for the purpose of this paper the apparatus may be described briefly as follows. A vertically mounted electrical resistance type furnace was used with a stainless steel sample block, and the whole heated to 1000°C. at a constant rate of 10°C. per minute. The furnace temperature was controlled and recorded with a Kent single-point temperature recording controller used in conjunction with a Kent type-7 gear box and a type 100-R adjustable transformer. The differential temperature was measured with a platinum 10 per cent rhodium-platinum thermocouple the output of which was amplified by a Tinsley galvanometer-type D.C. amplifier and recorded by an Evershed and Vignoles recording ammeter.

In examining the Tasmanian clays the sensitivity employed was such that the full chart width corresponded to an output of the differential thermocouple of 200 microvolts. Calcined alumina was used as a reference material and 0·8 g. of the whole sample was used in each run.

Chemical Analysis

Although no chemical analyses were made specifically for this investigation, records of the Division showed that analyses for industrial purposes had been made on a number of samples included in the present paper. The earlier work has greatly helped in making quantitative estimations of mineral composition by X-ray and D.T.A. methods.

Results

The compositions of the clay samples as estimated from combining X-ray, D.T.A. and chemical analyses are given in Tables II to IV. It will be seen that the clay minerals kaolinite, illite and mixed layer minerals together with quartz, felspar, gibbsite and hematite have been found present in the samples. No pure montmorillonite type clay mineral has been identified in any sample, although it forms a mixed layer mineral with illite in sample 11.

In estimating the mineral compositions set out in Tables II and IV it has been found necessary to appraise critically the accuracy of the various methods used. Thus the chemical analyses set out in Table I have been of value in giving an accurate estimate of the silica and kaolinite content of the samples and in enabling a correlation to be made with other samples by the D.T.A. method. X-ray examination, particularly of aggregates, has proved most effective in estimating the illite or hydrous mica content of clays especially when the quartz content is low. It, however, gives inaccurate results for quartz when this mineral is present in any quantity despite comparison with known quartz-kaolinite mixtures. It is considered that this error probably arises through variability in crystallinity of different kaolinites which affects the intensity of the diffraction pattern as a whole. The D.T.A. method gives, for kaolinites of comparable crystallinity, an accurate method of estimating the percentage of this mineral in the sample. However,

examination of standard illite-kaolinite mixtures has shown that up to 30 per cent illite may go undetected, due to near superposition of illite and kaolinite endothermic and exothermic peaks and the very low intensity of illite reactions compared with those of kaolinite. Although the kaolinite reactions are visibly reduced in such mixtures. in an unknown material this may be accounted for in other ways such as variable crystallinity of kaolinite or presence of quartz. Quartz has its $\alpha \leqslant \beta$ transformation at 578°C. completely masked by the kaolinite endothermic reaction at approximately 600°C. and so can be detected only on a cooling curve by the D.T.A. method if the kaolinite content is appreciable.

Estimates of the kaolinite content based on the area of the endothermic peak given in the differential thermal curve at about 600°C., when compared with those from chemical analyses, yield discrepancies which can be resolved only by assuming that kaolinites of different crystallinities and/or particle size distribution have different heats of reaction and thus different peak areas. The theoretical work of Spiel (1944) and Kerr and Kulp (1948) showed that the area under a peak in the differential thermal curve is proportional to the mass of a component present. It is to be expected that the less crystalline a component the lower would be its heat of reaction and the temperature of its peak. On the other hand varying crystal size has been reported by Spiel (1944) to influence the peak area whereas Berkelhamer (1944) could find no effect. Shearer (1949) on theoretical grounds also concluded that in the range of small particle size (2 μ and less) there would be no effect. Although we are in agreement with this conclusion the assumptions made by Shearer that the unit cell is completely broken down after the 600°C. endothermic reaction is not valid since it is well known that destruction of the lattice is complete only at about 900°C. Furthermore, material after heating to 600°C. can readily be re-transformed into a kaolinite type of mineral upon autoclaving. In a recent paper Bramao *et al.* (1952) have shown that the slope ratio of the descending to the ascending parts of the main endothermic peak varies inversely as the particle size.

Recent work by one of us (A.R.C.) agrees with that of Bramao *et al.* and has furthermore shown that although different fractions of a well crystallised kaolinite below 2 μ in size have different slope ratios they have the same peak area. We have thus concluded that discordant results in estimating kaolinite in the Tasmanian samples arise from kaolinites of different crystallinities having different peak areas and that to estimate accurately this clay mineral by D.T.A. a method is necessary for assessing its degree of crystallinity and correlating this factor with the area under the endothermic peak.

Clays from Dover

The compositions set out in Table II show that the Dover clays are generally very siliceous kaolinitic clays containing very small amounts of illite. Plasticity where present must arise from fineness of particles rather than from mineral composition. This fact is borne out by D.T.A. records which show from the asymmetric character of the endothermic peak at about 580°C. and the shape of the 980°C. exothermic peak, that the kaolinite is poorly crystalline in samples 1, 5, 7, and 6 (order of increasing kaolinite content). In samples 4 and 3 it is of medium, and in sample 2 of good crystallinity. This is illustrated in Fig. II (A, B and C) which shows the D.T.A. curves of samples 7 (poor crystallinity),

4 (medium crystallinity) and 2 (good crystallinity) taken under the same conditions, the kaolinite content being 55, 55 and 80 per cent respectively.

Clays from Surges Bay

Table III shows that the clays from Surges Bay are mainly kaolins derived from the breakdown of the felspars of the parent syenitic rock. Furthermore, the D.T.A. curves indicate that the kaolin is well crystallized in all samples. Although the illite and quartz contents are very low, sample 11 has been found to contain appreciable quantities of a mixed layer mineral of illite and montmorillonite. The presence of this mixed layer mineral is indicated in the D.T.A. curve (Fig. II (*d*)), by an endothermic peak at 690° C. following the kaolinite endothermic reaction at 620°C. In the X-ray patterns it is characterised by lines at 11·60, 5·01 and 3·20 A (in aggregate photographs) the first of which is replaced by two lines at 13·40 and 9·30 A upon glycerol treatment and the second and third by lines at 5·36 and 3·40 A, respectively. This behaviour can be explained as due to a random interstratification of 40 per cent montmorillonite and 60 per cent of a dioctahedral illite similar to that first suggested by Bradley (1945) for the clay mineral "bravaisite". The appearance of a line at 13·40 A rather than 17·7 A upon glycerol treatment could be explained as due to a random interstratification of trioctahedral clay mica and vermiculite units similar to that found by Walker (1949) for the decomposition of biotite in some Scottish soils. However, the bravaisite described by Bradley also showed incomplete expansion upon ethylene glycol treatment and furthermore the D.T.A. record, the dioctahedral nature of the intergrown structures and the behaviour of other X-ray reflexions upon glycerol treatment indicate that montmorillonite and illite form the intergrowth in sample 11.

Sample 11 is of additional interest in that its X-ray pattern shows a strong reflexion at 25·6 A, a further one is suggested at 47 A and both shift upon glycerol treatment to 28·8 and 51·5 A respectively. Two other prominent basal spacings at 4·58 and 3·056 A appear after glycerol treatment. These lines can be explained as due to an ordered interstratification of montmorillonite and dioctahedral illite sheets. Bradley (1950) has suggested an ordered structure of alternate units of pyrophyllite and vermiculite or contiguous pairs of pyrophyllite-like units separated by pairs of layers of water molecules for the clay mineral rectorite. However, the diffraction effects observed here differ from those of Bradley and have consequently been interpreted differently. Ordered structures of montmorillonite and illite have been reported from Queensland (Ferguson, 1950) and such complex structures may not be uncommon in Australian clays.

The possible occurrence together of ordered and randomly stacked structures of montmorillonite and illite has already been suggested by MacEwan (1949) but few samples have been reported in the literature. Further work is being done on the examples known to us and a more detailed account is to be given in a later publication.

Some aggregate photographs of sample 11 show a weak spacing at 16·4 A unaffected by glycerol treatment. This suggests an ordered stacking of kaolin and pyrophyllite or talc structures.

Much of the work on sample 11 has been carried out on fine fractions obtained by centrifuging a 2 μ and less fraction for several hours at

3000 r.p.m. This removed the kaolin which forms the bulk of the sample and left a finely divided suspension of mixed layer minerals from which aggregates were formed and powders obtained.

Clays from South Mt. Cameron and St. Helens

The compositions set out in Table IV shows that the clays from South Mt. Cameron and St. Helens are also mainly kaolins with the illite content low in all and the quartz content low in all but one. The colour of sample 13 is due to organic matter (detected by D.T.A.) and that of sample 14 to hematite. The kaolins of all samples are well crystallised.

Clay from Dunrobin Bridge

The composition set out in Table IV shows that the clay from Dunrobin Bridge is mainly a mixture of kaolin and gibbsite with a small amount of hematite. The characteristic exothermic peak in the D.T.A. curve at 350°C. (Fig. 2, E) is due to gibbsite and the slight one a little before 300°C. has been attributed by Pask and Davies (1943) to cliachite, a colloidal form of Al_2O_3. H_2O. The kaolin of the sample is not well crystallised.

Discussion

As yet too few samples have been examined to draw definite conclusions regarding the genesis of the clay formations but there are indications that the parent rocks have not exerted any marked influence on the products of their weathering. Little also can be said of the mode of formation of the mixed illite-montmorillonite mineral from Surges Bay, although the intimate stacking required would suggest a transformation from illite to montmorillonite or *vice versa*. The possible occurrence of an ordered kaolin and pyrophyllite or talc structure is also of interest and suggests that detailed sampling at Surges Bay might throw much light on the problem of the role of mixed layer structures on weathering.

Acknowledgments

The authors' thanks are due to Dr. J. S. Hosking, Officer-in-Charge of the Masonry Section of this Division, who collected most of the samples and suggested the investigation. Our thanks are also due to Mr. G. Hale of the University of Tasmania for permitting us to examine some of his samples from Dover and publish the results here.

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TABLE I

Chemical Analyses of Some Tasmanian Clays

	Dover			Surges Bay		
	4 HG_4	5 HG_1	6 HG_2	8	9	11
SiO_2	66·32	76·02	63·70	50·9	45·4	45·82
TiO_2	1·32	0·61	1·10	0·5	0·7	0·55
Al_2O_3	23·18	18·69	21·12	32·5	37·7	39·38
Fe_2O_3	1·89	0·24	5·02	1·7	1·8	0·16
CaO	...	...	....	....	....	0·22
MgO	0·82	0·33	0·33	...	....	0·06
K_2O	1·13	...	0·08	3·5	0·4	0·49
Na_2O	0·11	0·62	0·71	2·0	2·1	0·23
Loss on Ignition	8·96	6·06	8·72	8·8	11·9	12·67
	103·73	102·57	100·78	99·9	100·0	99·58

Sample 4. Brick sand clay. Analyst M. Neilson.
5. Highly siliceous plastic pipe and brick clay. Analyst M. Neilson.
6. Siliceous plastic pipe and brick clay. Analyst M. Neilson.
8. Gritty partly weathered clay. Analyst R. D. Hill.
9. Non-gritty paper clay. Analyst R. D. Hill.
11. Surges Bay clay of higher water content. Analyst M. Neilson.

NOTE.—These analyses have been prepared for industrial purposes and are not of high accuracy.

TABLE II

Estimates of Mineral Composition (in per cent) of Clays from Dover, Tasmania, as determined by X-ray, D.T.A. and Chemical Methods

	Brick sand clays		Whiting clays		Plastic pipe & brick clays		
Designation	1 DT_1	2	3 DT_3	4 HG_4	5 HG_1	6 HG_2	7* DT_2
Kaolin	30	80	65	55	40	60	55
Illite	15	<5	<5	10	<5	<5**	<10**
Quartz	60†	15	35	35	60	40	40
Felspar	Trace	....	N.D.	N.D.	N.D.	N.D.	Trace
Colour	Pinkish White	White	White	White	Cream	Cream	Brownish-White
Clay mineral of finest fraction	....	....	....	....	....	....	Kaolinite and hydrous mica
Origin of clays	Breakdown *in situ* of Permian sediments				Tertiary lake deposit?		

** Central scattering indicates uneven water layers suggesting a hydrous mica mineral rather than illite.
† Little to no quartz in the 2 μ and less fraction.
* This sample has a trace of organic matter.

TABLE III

Estimates of Mineral Composition (in per cent) of Clays from Surges Bay, Tasmania, as determined by X-ray, D.T.A. and Chemical Methods

Designation	Gritty, partly weathered clay	Non-gritty paper clays		
	8	9	10	11
Kaolin	65	85	85	65
Illite	<5	<5	<5	....
Mixed layer mineral	....	....	...	30
Quartz	....	....	<5	<5
Felspar*	35	15	....	....
Sodium chloride	Trace?	Trace?	....	....
Gibbsite	....	Trace?	....	....
Colour	White	White	Greyish White	White
Clay mineral of finest fraction	N.D.	N.D.	Kaolinite and illite	Mixed layer mineral
Origin of clays	Weathering of syenite *in situ*			

* The felspar in sample 8 contains both K and Na types, but that of sample 9 mainly Na.

TABLE IV

Estimates of Mineral Compositions (in per cent) of Clays from South Mt. Cameron, St. Helens and Dunrobin Bridge, Tasmania, as determined by X-ray and D.T.A. methods.

Designation	South Mt. Cameron			St. Helens		Dunrobin Bridge
	12	13*	14	15	16	17
Kaolin	75	85	80	75	55	50
Illite	10	10	10	10	10	<5
Quartz	<5	....	1 or 2	<5	35	....
Felspar	Trace	Trace	5	Trace	Trace	5
Hematite	....	....	10	....	....	10
Gibbsite	....	....	....	....	....	30
Colour	White	Cream	Yellow	White	Grey	Brown
Clay mineral of finest fraction	Kaolin					....
Origin of clay	Tertiary sediment derived from weathering of adjacent granite				Weathering of granite *in situ*	Clay underlying bauxite

* Contains organic matter.

Sample 16 contains much coarse gravel.

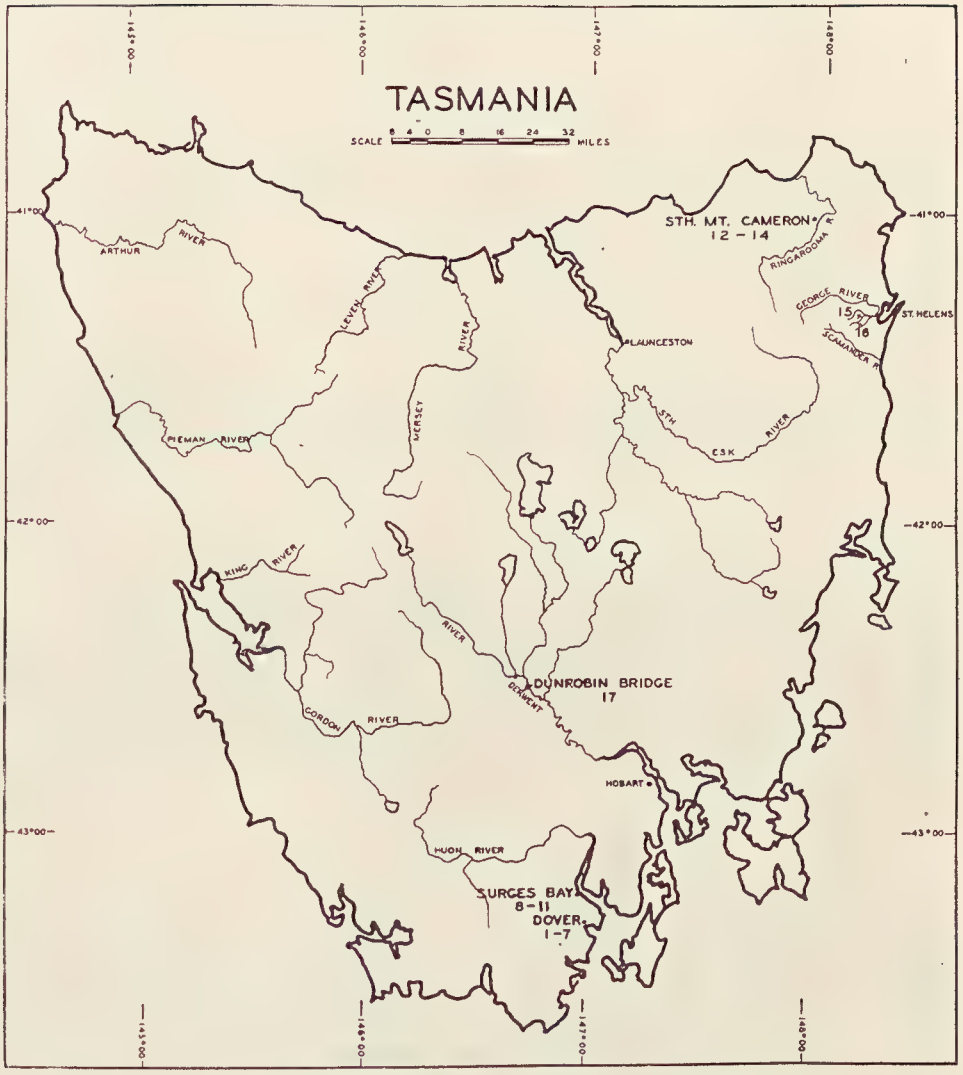

FIG. 1. Locality plan showing source of clay samples

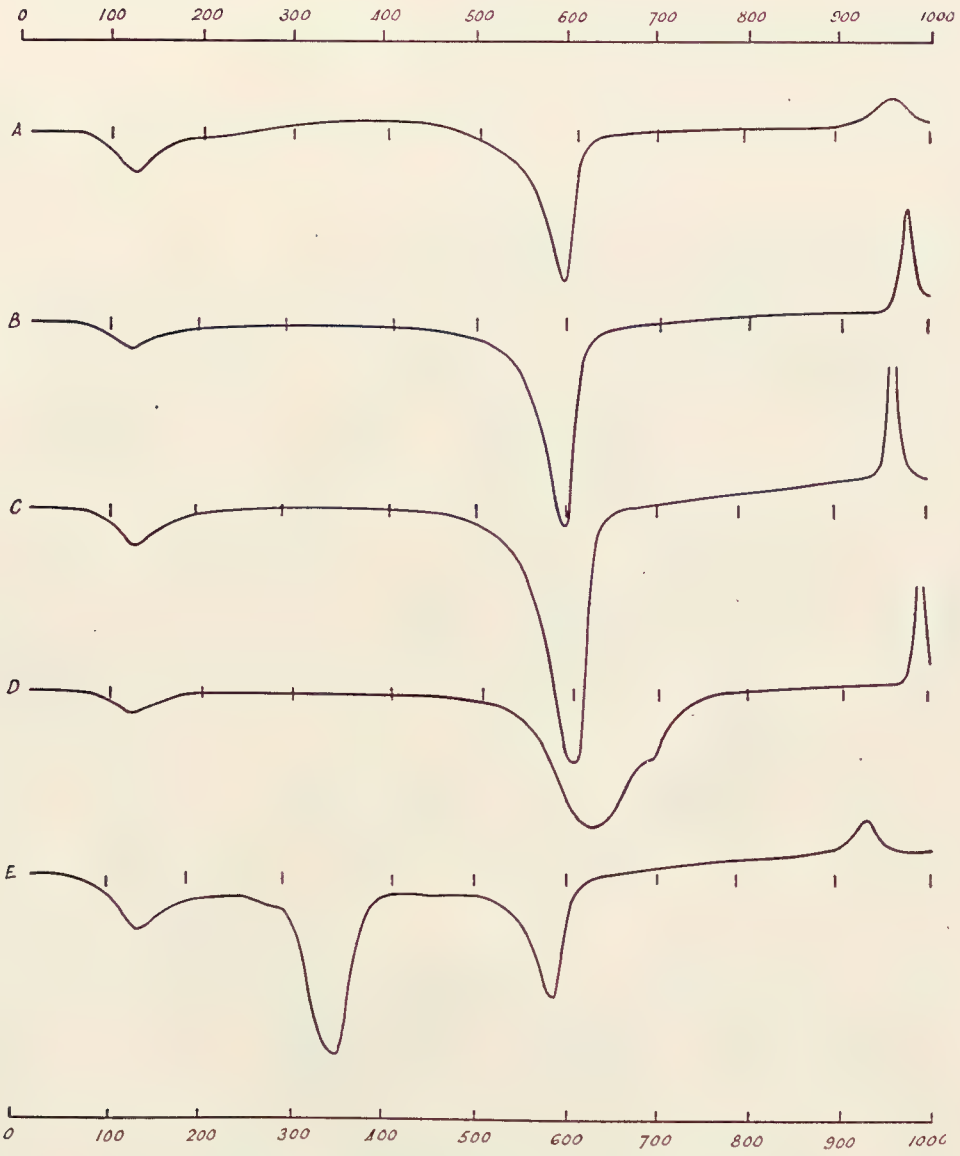

FIG. 2. D.T.A. curves of some Tasmanian clays

A. Sample 7 a plastic pipe and brick clay from Dover. Kaolin is of poor crystallinity; organic matter is present.
B. Sample 4 a whiting clay from Dover. Kaolin is of medium crystallinity.
C. Sample 2 a vein of white plastic clay in brick sand clays from Dover. Kaolin is of good crystallinity.
D. Sample 11 a paper clay from Surges Bay. Kaolin is of good crystallinity. The endothermic peak at 690°C. is due to a mixed layer mineral.
E. Sample 17 a bauxitic clay from Dunrobin Bridge. Kaolin is of poor crystallinity. The endothermic peak at 300°C. is due to cliachite and that at 350°C. to gibbsite.

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Chromosome Numbers in the Genus 'Pimelea'

By

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WITH 4 TEXT FIGURES

Summary

Chromosome numbers in 14 species of Pimelea were determined. A polyploid series with basic number x = 9 exists in the genus. Cytological examination has shown that *P. lindleyana* is specifically distinct from *P. spathulata.*

Introduction

In Tasmania the genus Pimelea is represented by about 18 species of which 6 are endemic. In most cases separation of the species is easy on classical morphological lines. However, the group of forms allied to *P. linifolia* have been variously treated by the earlier taxonomists. This cytological investigation was started in order to see if the confusion which existed between *P. spathulata, P. lindleyana, P. linifolia,* &c., could be resolved.

Experimental Methods

For somatic chromosome counts, divisions in apical meristems and very young leaves were stained in Feulgen (Darlington and La Cour 1947). In all the pubescent species, very careful dissection of the macerated and stained buds under the microscope was necessary to obtain preparations free from hairs which interfere with squashing. Some counts were checked on microtomed roots stained in crystal violet.

Pollen diameter was measured internal to the exine. Measurements were made of 15 grains from each of 10 plants in a population.

Results and Discussion

The chromosomes of the Pimelea species investigated were found to be small, averaging 2·5 microns in length. A comparative study of chromosome morphology was not possible since the treatments used rarely revealed the centromere constrictions.

Table 1 is a summary of the numbers determined. It shows that a polyploid series with a basic number of x = 9 exists within the genus, the mitotic counts being 36, 72, 90 and 108. The diploid remains to be detected. All species examined have fertile pollen and there is no evidence of any apomixis, &c., in the genus. In two dioecious species (both tetraploid) the numbers of males and females are approximately equal. A sample of *P. flava* from Glenorchy gave 49 males to 51 females, and a sample of *P. pauciflora* from Dunorlan gave 22 males to 17 females. No difference in the chromosome complement between male and female could be detected in either species.

Pollen diameter varies from 20·2 to 49·5 microns for those species measured. It is not directly related to chromosome number, the 12x species *P. drupacea* having smaller pollen than most of the 4x species. The close relationship of *P. spathulata* and *P. lindleyana* is, perhaps, reflected in their pollen diameters. By calculation from the pollen diameter of the 4x species *P. spathulata*, the expected diameter of the 10x *P. lindleyana* pollen is 49·2 microns which agrees closely with the measured diameter of 49·5.

As regards taxonomic treatment of the genus, the cytology shows that *P. lindleyana*, which was grouped by Rodway with *P. linifolia*, by Bentham partly with *P. spathulata* and partly with *P. linifolia* (Sm.) should be regarded as a separate species. *P. linifolia* is probably not a Tasmanian species.

As regards general classification of the THYMELAEACEAE, the family is a homogeneous one cytologically. The three genera, **Daphne, Edgeworthia** and **Wikstroemia** are reported by Darlington and Janaki Ammal (1945) all to have a basic chromosome number of 9. The family has been differently placed in the schemes of classification of the Dicotyledons drawn up by the various taxonomists. Engler and Gilg (1924) group the THYMELAEACEAE, and the ELAEAGNACEAE together as a suborder of the *MYRTIFLORAE*. Since the basic numbers of the ELAEAGNACEAE are 7, 10, 11, 12, 13 and 14, there is no cytological justification for this grouping. For other classifications (e.g., Hutchinson, 1946) the cytological data appear to be neutral at present.

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TABLE 1

Chromosome Numbers of Tasmanian Pimeleas

Species	Collecting Locality	Chromosome number (2n)		Pollen diameter (micron.)
P. cinerea R.Br.	Nieka			
	Mt. Wellington	36		28·6
P. curviflora R.Br.	Dunorlan	36		
	Launceston	36		
P. flava R.Br.	Glenorchy	36		27·8
	Murdunna	36		
P. glauca R.Br.	Triabunna	36		32·5
P. spathulata Labill.	Campania	36		36·5
	Collinsvale	36		
	Dry Creek	36		
	Dunorlan	36		
	Guildford Junction	36		
	Kingston	36	(fig. 1)	36·6
	Port Sorell	36		
P. ligustriana Labill.	Mt. Lloyd	36		32·5
P. nivea Labill.	Collinsvale	36		
	Glenorchy	36		34·1
	Sandy Bay	36		32·5
P. pauciflora R.Br.	Dunorlan	36		
	Launceston	36		
P. pygmaea F.v.M.	James River, Lake Augusta	36		
P. sericea (R.Br.)	Mt. Arthur	36		27·7
P. serpillifolia R.Br.	King Island	36		20·2
P. humilis R.Br.	Campania	72		
	Glenorchy	72		39·2
	Sandy Bay	72	(fig. 2)	39·8
P. lindleyana Meissn.	Hastings	90	(fig. 3)	49·5
P. drupacea Labill	Hobart	108	(fig. 4)	28·2
	Taranna	108		
P. axiflora F.v.M.	Not collected			
P. filiformis Hook.	Not collected			
P. milligani Meissn.	Not collected			
P. stricta Meissn.	Not collected			

FIGURES 1-4

Magnification x 1,500

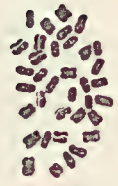

FIGURE 1

FIGURE 2

FIGURE 3

FIGURE 4

FIG. 1.—*Pimelea spathulata*. Kingston. 2n = 36 (Acetic alcohol — Feulgen)
FIG. 2.—*Pimelea humilis*. Sandy Bay. 2n = 72 (Acetic alcohol — Feulgen)
FIG. 3.—*Pimelea lindleyana*. Hastings. 2n = 90 (Acetic alcohol — Feulgen)
FIG. 4.—*Pimelea drupacea*. Proctor's Rd., Hobart. 2n = 108) Root tip, 2BD — C.V.)

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The Clay Deposit at Dover

By

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WITH 4 TEXT FIGURES

Abstract

A field and laboratory examination of the clay deposit at Dover showed that it consists of three types of clay, two of which are residual clays on Permian rocks while the third, a transported deposit, is probably of Tertiary age. Although the main constituents of all types are kaolinite, quartz and illite, they are easily distinguished by appearance and grain size analysis. It is considered that they are the products of ordinary weathering processes.

Introduction

The clay deposit of the Granton Brick Pty. Ltd. at Dover (see Hale (1953), this volume) is situated at the southern end of Hopetoun Beach on the western shore of Port Esperance at a distance of approximately $1\frac{1}{4}$ miles from the Dover Post Office. It occupies the small peninsula that forms the north bank of the Esperance River at its outlet into Port Esperance and is about $53\frac{1}{2}$ miles from Hobart. The area held by the company is approximately 30 acres.

In the immediate vicinity of the deposit the country consists of bush and bracken covered slopes leading up to a low escarpment beyond which extends a plain covered with a similar vegetation but interspersed with button-grass swamps. The whole is lightly sprinkled with eucalypts, generally of small size, and some patches of other scrub. The banks of the Esperance River are usually densely vegetated. The area provides a poor pasturage but is used in no other way at present.

The field investigation was carried out by drilling with a 4″ post-hole borer (hand operated) on a grid of 200 feet intervals. The clay was sampled at every detectable change of physical properties, such as colour, grain-size, and grittiness or, if no change occurred, every two feet. Later after some washing of the dumps had occurred, each waste pile was examined for fossils and rock fragments. By these means it was determined that there were three types of clay present and these types are referred to hereafter as DT^1, DT^2, DT^3. (See fig. 1.)

The investigation was made at the request of the Granton Brick Pty. Ltd. to ascertain the reserves of clay, if the clay could be differentiated into types, its firing characteristics, and to ascertain if the clay would be useful for purposes other than brick making.

Discussion of Results

An examination of the clay at Dover showed that the deposit there consisted of three main types which were called DT_1, DT_2 and DT_3 which can be differentiated visually and by grain size determination. It is

PORT ESPERANCE
ESPERANCE RIVER
E800 S1400
WO S1200
W400 NO
WO NO
DT 1
DT 2
DT 3
LEGEND
Quaternary System
RECENT SERIES
ALLUVIUM
Permian System
WOODBRIDGE GLACIAL FORMATION
GRANGE MUDSTONE
Jurassic System
DOLERITE
HOLES DRILLED
QUARRY
SCALE OF MILES
0 100 200 300 400 500

FIG. 1

considered that DT_2 is a transported clay of Tertiary age while the others have been formed by the weathering *in situ* of Permian sediments.

These clays were examined by petrographic methods, by Differential Thermal Analysis, by X-ray Diffraction photos, and dye tests. All tests showed that the clay minerals present are kaolinites with some illite. The only other abundant mineral is quartz.

The firing characteristics of the clays were tested, see tables I and II, and it was determined that better bricks could result from extrusion methods than from dry pressing the raw materials. All the clays tested showed that they could, at least, be used as the components of a low heat duty fire brick. Most of them showed a rather high absorption value indicating that little vitrification had taken place during firing. The colourless clay of the DT_3 type burns a white colour and shows a refractory nature. Both this and the DT_2 type could be used as ball clays in the manufacture of earthenware or pottery.

With careful preparation, these clays could be used to produce bodies of the terra-cotta, earthenware, stoneware, and china types; the iron content would be rather too high for producing porcelain. The clays have been used, especially the DT_2 and DT_3 white clay types, for slip-casting and art pottery with satisfactory results. The DT_2 clay yields a pink or cream porous body at about 900° C. At the same temperature, the DT_3 white clay produces a pure white rather denser body.

The grain size determination (see Table III) and firing tests showed that the clay of this deposit is a valuable source of raw material capable of producing a much higher grade of ware than at present. Other components, mainly silica in some form and felspar, would be necessary for such a product but these may be found locally. For instance, the felspar particles in the clay at Surges Bay or the syenite dykes of the Cygnet area may prove to be suitable for ceramic uses. The amorphous silica from the boulders of "grey-billy" in the clay deposit itself would serve as a raw material at the testing stage.

The estimated clay reserves are as follows:—

DT_1	4,038,000	cubic feet.
DT_2	4,995,000	cubic feet.
DT_3 total	6,450,000	cubic feet.
DT_3 white clay	70,000	cubic feet.

General Geology*

The clay deposit lies in a district composed of fault blocks of Permian and more abundant Triassic sediments intruded by transgressive bodies of Jurassic dolerite which has intruded along contemporaneous faults (see Hale (1953) this volume). Since this intrusion, further faulting, erosion, and eustatic change of sea level have produced the present topography.

The rocks recognised on the clay property are:—

Tertiary: DT_2 clay
Jurassic: Dolerite
Permian: Woodbridge Glacial Formation
Grange Mudstone Formation

* For greater detail see Hale, "Geology of the Dover District", this journal.

The dolerite outcrops on the southern tip of the peninsula and has a very straight contact with the fossiliferous Grange beds. The dolerite is fine-grained at the boundary and shows extremely close jointing. In places, it is cut by narrow veins of basaltic material which, in one place, is seen to intrude the sediments. The effect of the intrusion is variable but it usually has resulted in a hardening and fracturing of the intruded beds. The hardening seldom extends for more than a foot or two from the contact and in some cases is seen for less than an inch.

The tillitic Woodbridge Glacial Formation occurs under the Risdon Sandstone and above the Grange Mudstones. It is a massive conglomerate about fifty feet thick and shows great variation in grain size and composition. It is usually composed of a mixture of pebbles and boulders of granite, basic rocks, slates, schists, and quartzites with a matrix of angular quartz. It is cemented with some iron compounds and argillaceous material and is unfossiliferous. It is thought that, in the clay deposit, it has weathered to form the DT_1 type of clay.

The Grange Mudstone underlying this can be traced along the shores of Esperance River from Ghost Corner to its mouth and from the dolerite boundary there along Port Esperance to the first point south of the brick making plant. In this area, the grain size and composition and therefore the appearance of these beds are extremely variable but everywhere it is characterised by the presence of abundant fossils of Permian age. The weathering of those beds gives rise to the DT_3 type of clay which also yields fragments of fossils in nearly every hole. These mudstones also carry pebbles of granite, slate, schist, and, more often, quartzite but these erratics are small and their occurrence sporadic.

Although close jointing is very common in all the sediments, no large faults can be detected in the clay deposit. It is possible that some faults with a throw of less than 50 feet are present but the lack of beds which can be correlated over the area make it impossible to find these structures. The whole of this block extending from Dover to beyond Raminea, despite its low topographical aspect, lies in an upthrown block for this is the only place in the area that the Grange Mudstone, the oldest stratigraphic unit at the surface, outcrops.

The Origin of the Clays

There are three mechanisms by which this clay deposit could have been formed; hydrothermal action along faults, igneous activity, and weathering.

The first is eliminated by the absence of any appreciable faulting in the area under consideration. The deposit is traversed by many joints and perhaps by some small faults with throws of less than 50 feet but nowhere are these emphasised by the clay profile to a noticeable extent.

In the second case, no igneous rocks except the dolerite can be suspected to have had any influence in the area. No signs of a surface flow of basalt appear in the district and the possibility of a deeper intrusion unrevealed at the surface is discounted by the fact that the clay deposit is shallow and lies over a solid rock floor. The effect of the dolerite is very limited elsewhere and usually results in a hardening of the intruded rocks not kaolinization; therefore it would be unwise to consider this the cause of the clay formation.

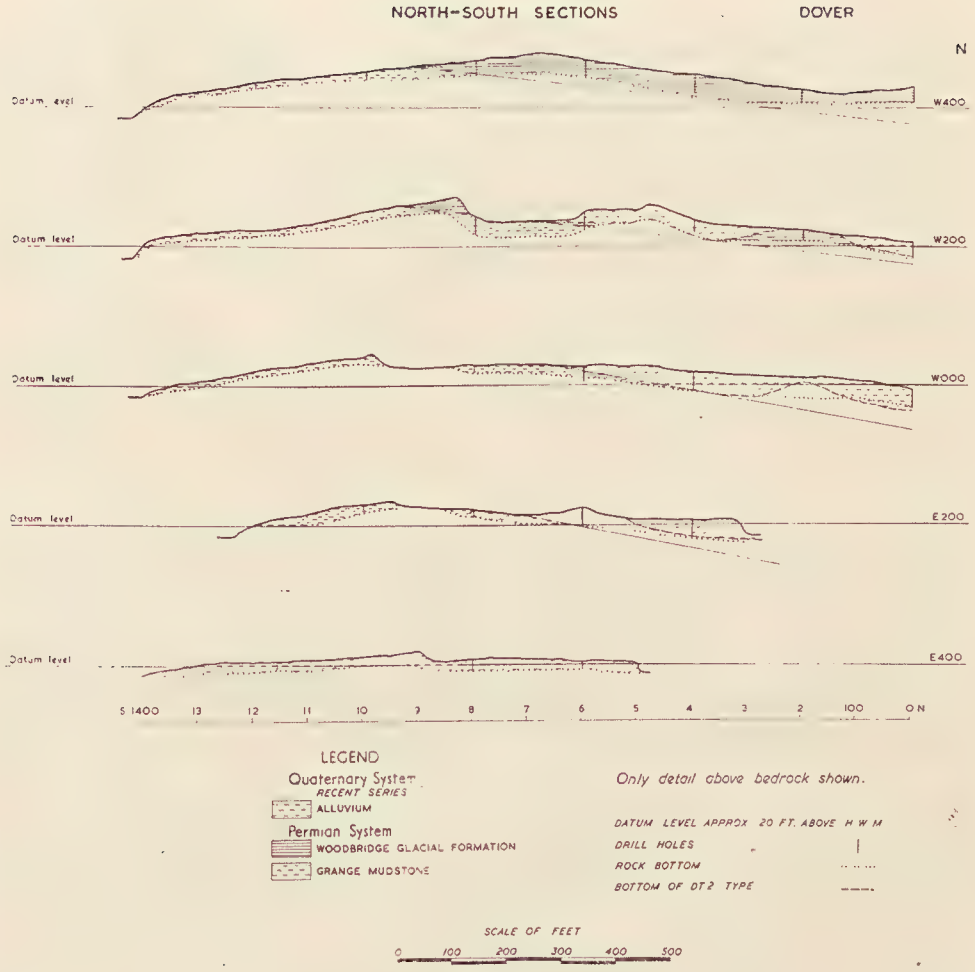

FIG. 2

A feature of the whole of the Dover area is the deep weathered zone. Away from the streams and shores, rocks outcrop rarely and the soil cover is usually between 5 to 10 feet deep. Also the bottom of this deposit everywhere shows a relationship to the water table depth often paralleling the ground surface. (See sections Figs. 2 and 3). The important exception to this is in the area occupied by the DT_2 type of clay.

The type of pebbles and boulders, arranged in the same sort of pattern, is common to the adjacent sediments and the DT_1 and DT_3 type of clay. There is a similar banding in the rocks and the higher parts, i.e., the DT_1 clay, shows a high iron content and the lack of stratification typical of the adjoining Woodbridge beds. Below this, the DT_3 type of clay carries the same fossils as the lower Grange beds. As the Risdon Sandstone outcrops along the low escarpment above the deposit, the stratigraphical position of these beds supports the idea that the DT_1 and DT_3 type of clay have been produced by the weathering *in situ* of the Grange and Woodbridge beds, i.e., they are residual clays.

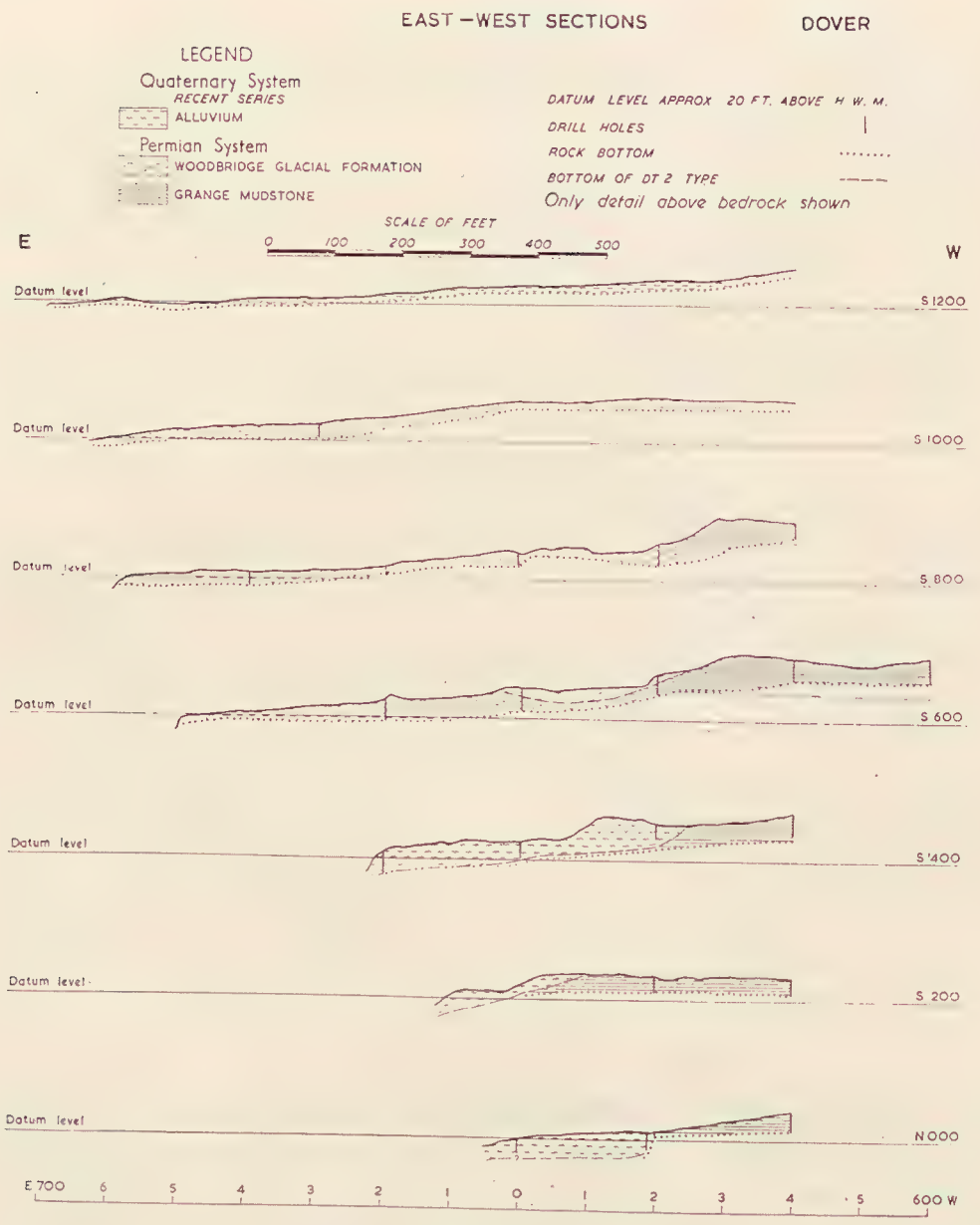

FIG. 3

However, the DT_2 type is of a different nature. An examination of the grain size distribution by means of the cumulative curves, clearly shows that it is a much better sorted deposit than the other two. All the coarse material has gone or, perhaps, was never available in the depositional environment. The cleanly segregated fine sandy patches as well as the fossil tree trunks with their outline of coarse sediments—the result of turbulence around the logs—suggest a subaqueous deposition.

Beyond the lignitic trees or odd pieces of plant fragments, no fossils were found in this clay. At this stratigraphical level, there is no known bed that would yield such a clay by weathering *in situ*.

The grain size analysis suggests that this is a secondary clay, i.e., it has been formed by deposition of clay in a lake. In particle size, it resembles the clay that is being shed from the dolerite at the present time.

No age for the formation of this clay is known but it may have been deposited in the Pleistocene in a period of high sea-level and revealed by the lowering of the sea-level in the last ice age or it may have been deposited in a Tertiary fault lake.

The boulders of silicified material often encountered in the deposit could be " grey-billy " or, as seems more likely, it could have been formed as a siliceous deposit in the B horizon of a soil profile. This is supported by the existence in many places of a siliceous hardpan overlying the clay material.

Description of Clays

(1) DT_1

This type of clay material which by its grain size analysis (see Fig. 4) must be classified as a clayey silt rather than a clay is found in the north-west section of the property.

The colour of this material is variable. Extensive patches are distinctly pink due to disseminated haematite but it is more usual to find it mottled, white, pink and yellow, or yellow in colour. In some places the material consists of alternating bands a few millimetres thick of yellow and white colour and occasionally red bands either with the white or yellow.

The main beds are often cut by narrow ramifying veins of white plastic clay (kaolinitic)* which has leached into cracks and openings in the massive material. At the bottom of all holes completed in this area the material recovered was extremely rich in angular quartz and the texture of the material resembled that of the Risdon Sandstone.

Drilling in this material is easy but, unless the hole is damp, its sandy nature makes recovery difficult. At intervals, beds a few inches thick of pebbles and cobbles up to 2″ in diameter are encountered. These are usually quartz or quartzite but pebbles of black slate and schist have been found. The distribution of the bands is apparently haphazard.

From the list of holes it will be seen that this deposit is fairly thick. One hole (W 400 S 400) exceeded the length of the drill rods and showed no bottom at 32′. It is estimated that this deposit contains 4,038,500 cubic feet of material or roughly 72,616,000 bricks.

No fossils were seen in any of this material but at W200 S800 it is seen to overlie the fossiliferous Grange Mudstone. Thus its stratigraphic position supported by the haphazard distribution of pebble bands, and the species of pebbles found suggest strongly that this is a weathered portion of the Woodbridge Glacial Formation which is poorer than usual in erratics.

This material disaggregated easily in water and rapidly settled out into a silt and a clay fraction. Grain size determinations were carried out by both the pipette method and the hydrometer method. Both showed that as much as 69% of the material was above the clay grade size.

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* See Cole and Carthew, 1953, this volume.

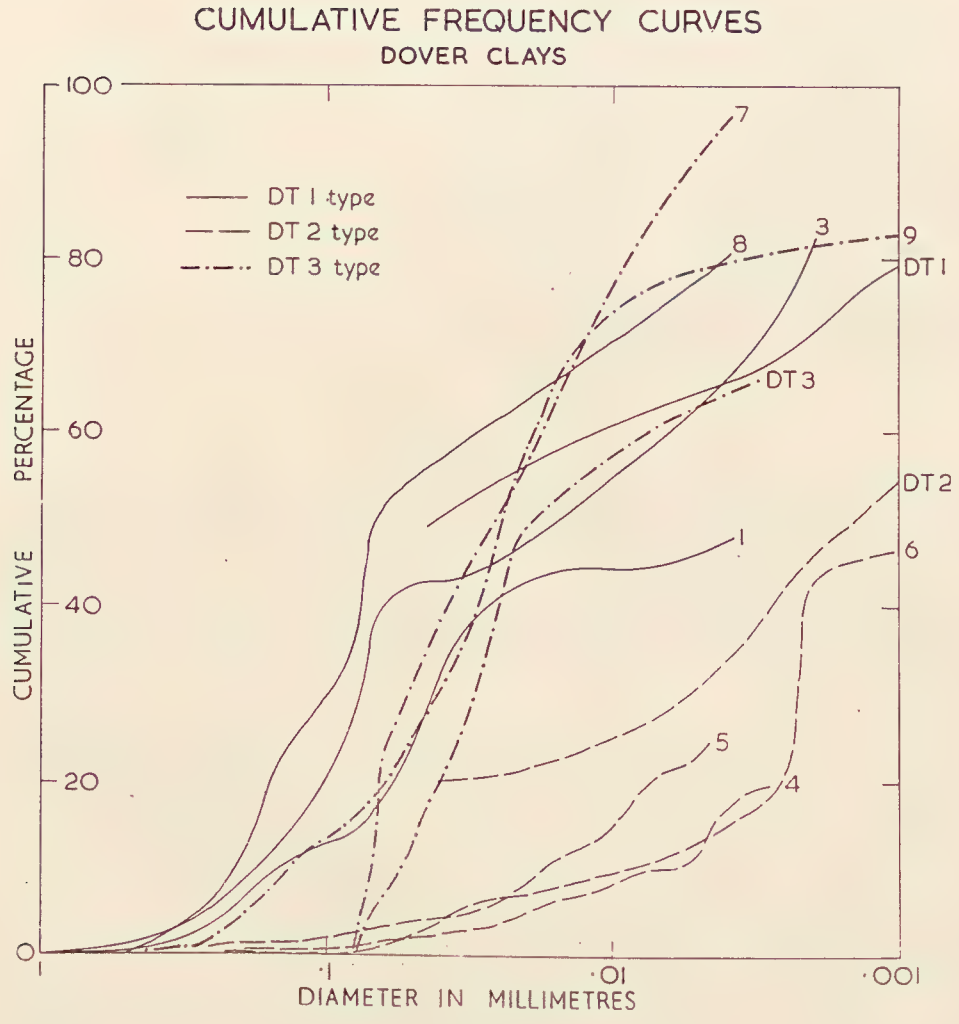

FIG. 4

The samples determined were:—

DT_1 A channel sample from the top quarry
W200 S600
W400 S400
W400 S800

As well as the kaolinite, quartz, and illite identified by Cole and Carthew (this journal), the following heavy minerals have been identified in this clay from the hole at W400 S800:—tourmaline (brown), rose garnet, black spinel, pyrite, limonite, rutile, brookite, haematite, and apatite.

The light fraction, composed mainly of clear vitreous and iron-stained angular quartz, contained felspar (usually heavily kaolinized) talc, quartz, mica schist, and carbonaceous material.

(2) DT_2

The area occupied by this bluish-white extremely plastic clay is shown on the map. The hole at E200 S600 was at first thought to be in this material but the whiteness of the fired material from this hole indicates that it is part of the DT_3 material.

This type of clay has been found in the bore holes to overlie the DT_3 type and, along the shore at E400 S500, it again overlies this clay with an undulatory contact which dips northward at about 10°.

Its relation to the DT_1 type is not entirely clear as the surface of both is covered with fine quartz sand. However the hole at the W200 S600 shows what appears to be this type of clay over the DT_1 type.

When fresh and wet this clay shows considerable variation in colour. Some dark brown beds owe their colour to carbonaceous matter which everywhere may be traced by blue, orange, and yellow stringers in the clay. Nodules of red haematite occur in many places. The occasional sandy patches are usually of a mauve colour. The top few feet are stained by the transportation of iron oxide to various shades of red and yellow.

On the foreshore at E300 S380, the outline in sand and the brown colouration of fossil trees can be seen. Some lignitic material can be collected from parts of these trees. Similar lignitic wood stopped drilling in the hole at W0 S400. An age determination of these trees is being investigated by Dr. Mary Calder of Manchester University but, as yet, there is no indication of the age of these beds.

Large limonitic concretions up to 10 feet across occur in this clay and especially near the base of it. Sandy lenses and occasional pebbles occur at infrequent intervals. The reserves of this clay are estimated to be 4,995,000 cubic feet, i.e., 79,920,000 bricks.

The clay is extremely hard to bore and is practically impervious to water when compacted. A green colour later turning to orange and brown often appears on slickensided surfaces.

The grain size analyses, carried out by the pipette and hydrometer methods, show that 55% of the material is in the clay grade, and of the total, 34% is smaller than ·65 mm. in diameter.

This clay is a very plastic one and the smaller particles would not deposit completely even after lengthy centrifuging. For the fine aggregate used in the X-ray determination, this suspension was flocculated with $CaCl_2$. The clay broke down after soaking for 24 hours in water containing sodium oxalate.

Samples were selected as follows:—

DT_2 — Channel sample from the hole at E200 S400.
IV — W200 S600 No. 5.
V — W200 S400 No. 18.

The chief minerals present are kaolinite, quartz (especially in the submicroscopic grades) some illite, felspar, garnet, rutile, tourmaline, spinel, pyrite, limonite, and some white mica. Marcasite was also found replacing rootlets.

A specimen from hole W200 S400 gave the following trace elements*:

Ni	Cu	Zn	Mo	Mn	Va
32&38 ppm†	12&11 ppm	20&24 ppm	4 ppm	70&68 ppm	440&435 ppm

(3) DT_3

The remaining area, except that occupied by the dolerite, is covered with a mantle of clay of the DT_3 type. This mantle is never as thick as in the other areas, the deepest hole in it, at E300 S1000, reaching a depth of 23′ 2″.

The clay is composed of two types. One is a clayey silt of yellow or reddish yellow colour and bearing abundant fragments of bryozoans and brachiopods. This is similar in colour to the DT_1 type but does not contain as high a proportion of quartz sand. The other component is white, cream or sometimes brownish in colour and is essentially a non-gritty plastic clay. This white clay outcrops at the small clay pit and in the bank at E200 S600. In both types, fragments of angular quartz, quartzite, slate, and schists (micaceous and garnetiferous) up to 2″ across have been found.

Along the shore, this clay overlies the Grange Mudstone and as the fossil content, the erratics and the bed of tillitic conglomerate which outcrops on the shore at E437 S600 are seen elsewhere in the district to be typical of this formation in its unweathered state, it is considered that DT_3 is a product of the weathering of the Grange Mudstone.

If this is so and the patches of white clay are not formed *in situ*, it is almost certain that this clay will be found distributed as lenses or pockets in the coarser yellow material and not confined to any one horizon.

The behaviour of this clay in drilling is variable. The fine plastic patches such as at W400 S1200 are fairly tough but not as tough as the DT_2 clay while the sandy portions such as found at E300 S1000 are fairly friable.

The total reserves of this clay are estimated to be 6,450,000 cubic feet or 103,200,000 bricks. Of this about 70,000 cubic feet or 1,120,000 bricks is contained in the known deposits of white clay.

As with the other types, the most abundant mineral present was kaolinite. Quartz was less abundant than in the DT_2 type and there was the usual small amount of illite present. No heavy mineral separation was carried out on this type.

Acknowledgment

I desire to thank the Directors and Officers of the Granton Brick Pty. Ltd. for the opportunity to do this investigation, for the ready help given in transport and accommodation and for their permission to publish the results of the examination.

My thanks are due, also, to Professor S. W. Carey of the Geology Department, University of Tasmania, who suggested that I should carry out this work and who, together with his staff, advised me at all stages of the work.

I am deeply indebted to the Masonry Investigation Branch of the C.S.I.R.O., Highett, Victoria, which is administered by Mr. I. Langlands who, at the time of my study there, was deputised by Dr. J. J. Hosking.

* Determination by R. J. Ford, Geology Department, University of Tasmania.
(† ppm—parts per million.)

The course of the investigation at Highett was directed by Dr. Lex Ferguson. Dr. H. Heuber gave help with chemical and burning problems; Mr. Holland with the preparing of specimens for firing. Dr. W. F. Cole took X-ray Diffraction photographs, calculated the spacings, and interpreted them; Mr. A. Carthew* produced D.T.A. curves and gave instruction in the grain-size analysis by the hydrometer method. To all these officers I wish to express my thanks for their assistance.

LIST 2

Holes Drilled

Hole		Depth	Reason for Stopping
W 600	S 600	28′ 6″	
W 400	N 0	25′ 9″	Rock
W 400	S 200	25′ 3″	Rock
W 400	S 400	32′	End of drill rods
W 400	S 600	32′	Rock
W 400	S 800	22′	Rock
W 400	S 1000	10′ 2″	Rock
W 400	S 1200	8′ 10″	Rock
W 400	S 1400	6′ 5″	Rock
W 200	N 0	24′	Rock
	S 200	15′	Rock
	S 400	21′	Hole caved in
	S 600	24′	Rock
	S 800	30′ 2″	Soft Rock
W 0	N 0	21′ 6″	Hole caved in
	S 200		Under the plant
	S 400	23′ 5″	Stopped in lignitic wood
	S 600	30′ 9″	Rock
	S 800	15′ 6″	Rock
	S 1000	3′	Hardpan under sand
E 200	S 4400	32′ 8″	Rock
	S 600	30′ 9″	End of drill
	S 800	10′ 4″	Rock
	S 1000	1′	Hardpan
E 300	S 1000	23′ 2″	Rock
E 400	S 525	8′	Rock
	S 600	13′	Rock
	S 800	20′ 4″	Rock

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* For greater detail see Cole and Carthew, 1953, this journal.

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TABLE 1

Firing Characteristics of Hand Moulded Samples.*

	$DT_{1\&2}$	DT_A	DT_B	DT_C
Firing Temp. (in °C.)	1100	1150	1100	1100
Tempering H_2O	32%	31%	34%	36%
Water Absorption	22·2%	23·2%	21%	20·3%
Total Shrinkage	10·7%	10·4%	11·7%	12·2%
Warpage	nil	some cracking and deformation in one sample.	nil	nil
Cohesion	good	good	good	good
Vitrification	beginning	beginning	beginning	beginning
Remarks	Samples burnt in muffle kiln are pinkish orange at low temp. but pale pink by 1100°C.	As for $DT_{1\&2}$	As for $DT_{1\&2}$	As for $DT_{1\&2}$

* This firing was carried out in a gas-fired kiln and the details supplied by Dr. J. A. Ferguson of the Masonry Investigation Branch, C.S.I.R.O., Highett, Victoria.

TABLE 2

Firing Characteristics of Dry Press Samples*

	DT_1	DT_2	DT_3	DT_{1+2}	DT_A	DT_B	DT_C	DT_E
Firing Temp. (max.)	1100°C	1100	1100	1100	1100	1100	1100	1100
Tempering H_2O	nil	nil	nil	nil	nil	nil	nil	6% + ·6% Na_2CO_3
Water Absorption	16%	24%	25%	21%	21·5%	21·5%	21%	
Warpage	nil	nil	nil	nil	nil	nil	nil	nil
Shrinkage	nil	nil	nil	nil	nil	nil	nil	nil
Cohesion	fair	poor	poor	poor	poor	poor	poor	good
Colour (at max. temp.)	light greyish orange pink; flecks of red.	grey pink thickly flecked with red. Cream colour increases with temp.	white	flecked orange pink to yellow grey.	flecked orange pink to yellow grey.	flecked orange pink to yellow grey.	flecked orange pink to yellow grey.	orange pink
Vitrification	nil	nil	nil	nil	nil	nil	nil	some bonding developed.
Remarks	At 1450°C: vitrified; grey to white colour; not deformed		At 1580°C: vitrified; not deformed white with black spots.	1580°C:— brown; white vitreous with hard edges.	1580°C:— light grey and brown mottled; vitreous with hard edges.	1580°C:— darker than A and some melting on the edges.	1580°C:— similar to other but some melting at edges.	A much harder brick than the others.

* Fired in an electric muffle kiln.

TABLE 3

List 1—Mechanical Analyses

Diameter mm.	Cumulative % greater than given Diameter								
	DT_1 TYPE				DT_2 TYPE			DT_3 TYPE	
	DT_1	1	3	8	DT_2	4	5	DT_3	7
1·000	....	·036	....	·26	....	....	....	....	....
0·5	....	·443	·1	1·21	...	...	...	...	·04
·2945	...	2·19	·34	3·16	....	·02	·078	....	·12
·1522	...	10·18	11·9	21·56	....	·36	1·166	....	·55
·0761	...	14·11	30·5	38·59	....	·75	2·35	1·66	1·04
·0625	....	..	41·5	52·06	....	1·88	3·34	....	23·44
0·44	49·6		42·8	..	20·00	2·04	4·63	...	...
·0312	....	38·37	....	60·16	....	....	5·50	26·58	44·76
·023	55·6	..	46·2	...	21·8	....	7·23	46·72	..
·0156	....	44·34	50·5	65·08	....	6·17	11·20	....	64·37
·011	59·4	....	53·5	....	24·7	7·83	13·62	...	....
·0078	....	44·76	53·5	73·34	....	9·99	19·10	....	81·69
·006	63·7	....	61·5	....	30·6	.	....	..	..
·0039	....	...	67·1	82·30	...	17·12	26·60	....	95·48
·00276	...	...	71·1	....	....	19·57	....	61·91	....
·0024	69·4	....	...	....	44·4	..	.	....	..
·00195	....	52·67	82·5	...	....	.	..	..	...
·0013	77·9	...	....	....	54·4	..	.	..	...
·00068	84·4	....	....	....	65·7	....	...	.	...

Syndactyly in the Manus of a Marsupial

By

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(WITH PLATE I AND ONE FIGURE IN THE TEXT)

The wallabies and their allies (Macropodidae) normally have the typical mammalian pentadactyle manus.

A male pouch embryo of the wallaby, *Thylogale billardierii* (Desmarest), from Lake Leake, Tasmania, has been found with both the left and right manus abnormal. The specimen was collected in June, 1946, and is housed at the Tasmanian Museum, Hobart. Principal dimensions; head and body length 95·0 mm., head length 25·5 mm., tail length 22·0 mm., ear length 7·0 mm. and pes length 14·5 mm.

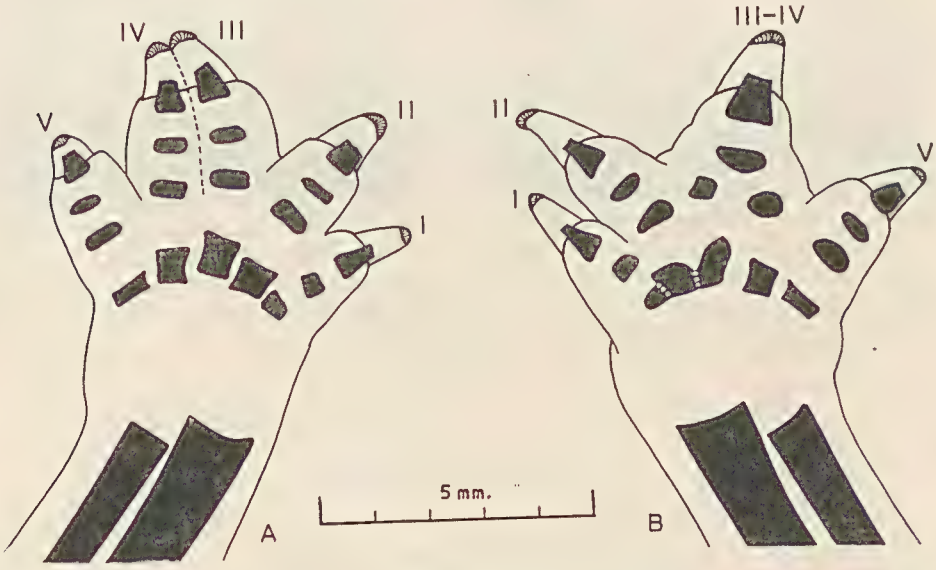

FIGURE 1

Thylogale billardierii.—Abnormal pouch embryo from Lake Leake, Tasmania.

A. Right manus drawn from radiograph. Although digits 3 and 4 are externally partially syndactylous the metacarpals and phalanges are normal. Note the absence of centres of ossification for the carpal bones in both the right and left manus. Also, note the deciduous claws (shaded) on the ends of the permanent claws.

B. Left manus drawn from radiograph. Digits 3 and 4 are externally completely syndactylous. Of the phalanges of these digits, the proximal ones are separate but the middle and distal ones are fused. Also, note that metacarpals 1, 2 and 3 are abnormal.

In this unique specimen digits 1, 2 and 5 are normal but digits 3 and 4 are conjoined. On the right side, digits 3 and 4 are partially syndactylous (Pl. I, A); a condition which immediately reminds one of the well known combined 2nd and 3rd digits in the pes of many marsupials. The conjoined digits are enclosed in a common skin and bear two distinct claws which, except at their distal ends, are fused. On the left side, digits 3 and 4 are externally completely syndactylous (Pl. I, B) and together bear only a single claw. Deciduous claws, similar to those described in the bandicoots, *Isoodon obesulus* and *Perameles gunnii* (Lyne, 1952, pp. 634-635), are still retained on the ends of the permanent claws.

In order to interpret their bony structures without dissection both abnormal fore limbs have been X-rayed. In the manus with partially syndactylous digits (fig. 1, A) the metacarpals and phalanges are normal. There are five metacarpals, one at the base of each digit. The first digit has two phalanges while each of the other digits has three. In the manus with digits 3 and 4 externally completely syndactylous (fig. 1, B) some of the metacarpals and phalanges are abnormal. Metacarpals 1 and 2 are in close contact and appear to be fused. Proximally, metacarpal 3 is in close contact with metacarpal 2 and may or may not be fused. The phalanges of digits 1, 2 and 5 are normal but those of the fused digits are abnormal; of the phalanges of digits 3 and 4, the proximal ones are separate but the middle and distal ones are fused.

In neither manus does the radiograph show any sign of the carpal bones or distal epiphyses of the radius and ulna.

It is interesting to compare the manus of this marsupial with that of a full-time human foetus. In the human the carpus is cartilaginous at birth whereas the metacarpals and phalanges are well ossified (Jamieson, 1947, p. 262). The centres of two carpal bones, the capitate and hamate, appear six months after birth but the remainder of the carpal bones do not appear until much later. The primary centres of the metacarpals and phalanges appear between the eighth and twelfth week of intra-uterine life and at birth these bones are well ossified.

Acknowledgments

For the opportunity of examining this unique wallaby, I am indebted to Dr. J. Pearson of the Tasmanian Museum. Also, I wish to thank Dr. D. J. Rae, of Hobart, for the radiographs from which figures 1, A and 1, B have been drawn. Finally, I wish to thank Mr. D. W. Peacock who provided the photographs reproduced in Pl. I.

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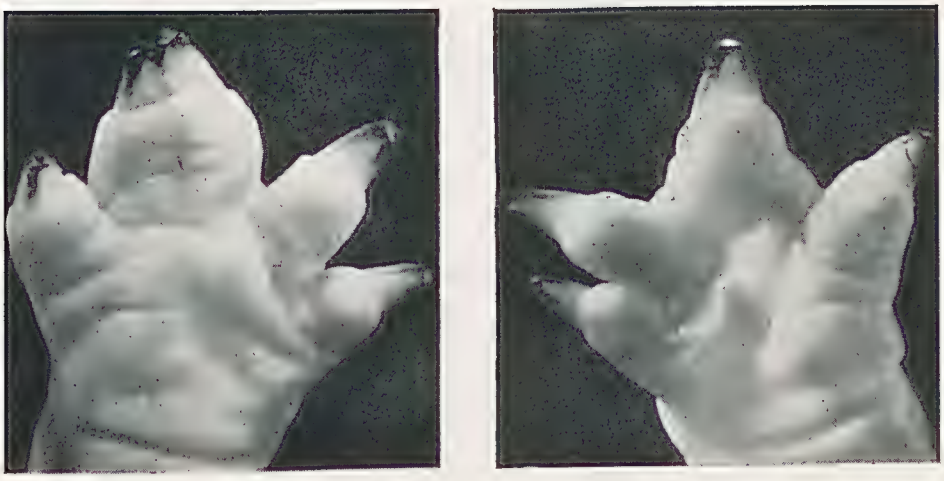

A B

Thylogale billardierii.—Abnormal pouch embryo from Lake Leake, Tasmania.

Figure A: Right manus, palmar aspect. Instead of the manus having a normal pentadactyle structure, digits 3 and 4 are partially syndactylous.

Figure B: Left manus, palmar aspect. Instead of the manus having a normal pentadactyle structure, digits 3 and 4 are externally completely syndactylous.

Pap. & Proc. Roy. Soc. Tasmania, Vol. 87 (15th August, 1953)

Contributions to the Freshwater Microfauna of Tasmania

Part 1 — Copepoda

By

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Biological Station, Lunz, Austrian Academy of Science

WITH 67 TEXT FIGURES

Preface

The following communications owe their creation to the friendly courtesy of Dr. A. G. Nicholls, who let me have the freshwater material, collected during a lengthy stay in Tasmania, for the zoogeographical evaluation. Here, too, Dr. A. Komzak should be thanked most cordially for the translation into English.

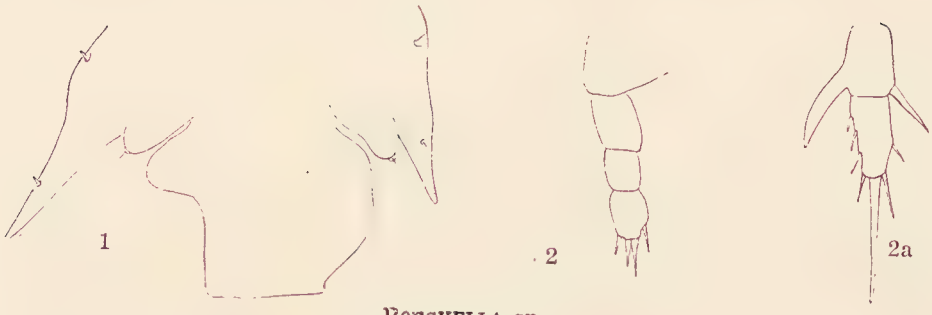
Since the evaluation of the various animal groups necessarily takes a rather long time and also the distance of the place of publishing from Europe entails considerable delays, I prefer not to wait for the completion of the whole work before the printing is begun. Instead, I propose to submit the results in three consecutive sections of which this, the first, comprises the Copepoda. The second is to deal with the remaining Entomostraca, the third with the Amphipoda as well as further animal groups and the zoogeographical results. As some samples were abundant in Diatomeae, a further communication on these is planned by Dr. Hustedt.

I wish to thank Dr. M. Beier from the Vienna Imperial Museum for the procurement of several papers. Although the zoogeographical discussion of the found species is reserved for the final section, it may be stressed already here that the species described as *nov. spec.*, and also those compiled by Smith, cannot be considered to be Tasmanian endemisms. They will certainly be found in adjacent parts of the Australian Continent.

Centropagidae

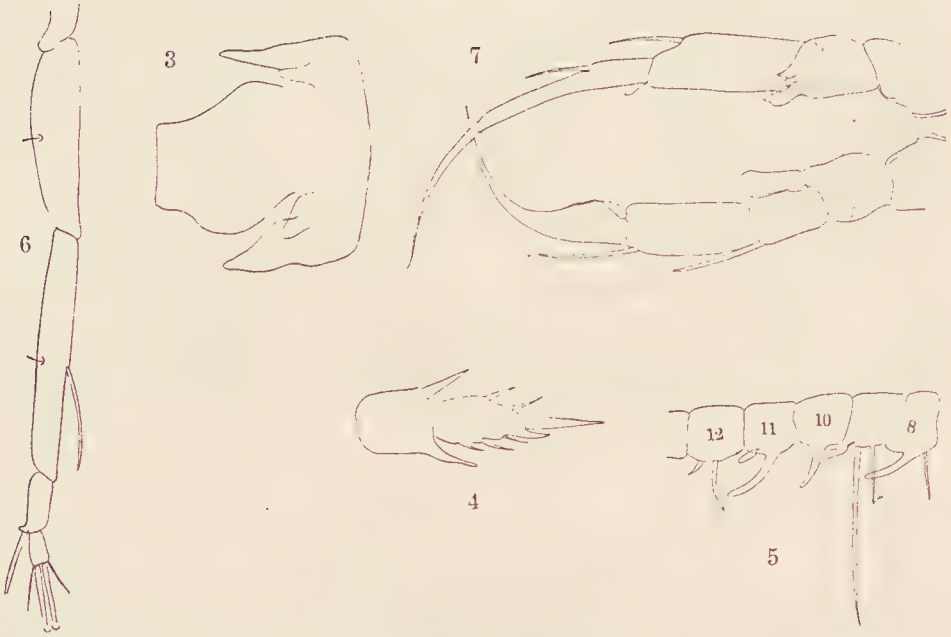
Boeckella sp. (Figures 1, 2)

The sample T 4 from Lake Dobson contained 20 specimens of a *Boeckella*, unfortunately females throughout. The lack of the male renders the safe determination impossible. The animals, about 1350 μ long, partly bore egg sacs, each containing only 4 eggs. The last thoracic segment is strongly winged, the external wings are pointed and reach up to the middle of the genital segment. The genital segment possesses on the left side a globular protuberance, the right side bulges along its entire



BOECKELLA sp.

1. End of thorax and genital segment, ♀
2. Fifth leg, exopod and endopod, ♀



BOECKELLA DENTICORNIS n. sp.

3. End of thorax and genital segment, ♀
4. Fifth leg, terminal part of exopod, ♀
5. Spine-like appendages of gripping antenna
6. Terminal portion of gripping antenna
7. Fifth pair of legs, ♂

length. The claw of the second segment of the external branch of the fifth leg is smooth, moderately large, the third segment of the external branch bears seven appendages, all of which are very small, with the exception of the terminal spine, which is quite double the length of the terminal segment. The last segment of the three-segmented endopod bears few—mostly four—quite short spines. There are, as visible in our picture, small sensory setae on both flaps of the thoracic wings.

Boeckella denticornis n. sp. (Figures 3-7)

Female: red coloured. Egg sacs consisting of about 20 eggs. Length: 1800 μ. Antennulae reaching at least up to the end of the furcal setae. Thoracic wings very long, reaching to the end of the genital segment. The genital segment asymmetrical, exhibiting on the left anterior side one, sometimes two protuberances, bulging on the right side in the middle. The exopod of the fifth leg is conspicuous by the relatively weak claw of the middle segment, which is, for that matter, smooth (exhibiting a feeble hair fringe only at great magnifications) and mostly not much stronger or longer than the spine on the external side of this segment. The terminal segment is provided with 7 appendages, of which those on both inner and outer side are conspicuous by their shortness.

Male: 1600 μ long. The thorns of the 8th and 10th segments almost equally large, that of the 11th segment mostly somewhat smaller. The 12th segment bears, distally from the sensory spine, a seta with a bulbous swelling at the base. The penultimate segment bears at the distal end of the curved side a small, tooth-like appendage, reminiscent of the tooth of the terminal segment of the antennule of *Diaptomus denticornis* *. The short terminal segment is oriented obliquely to the segment before it. The last thoracic segment is without wings and bears on each side a small sensory seta. Fifth leg on the right: second basal with a small tooth on the inner margin. The bristle on the external margin short. Beside the endopod a flap-like extension. The segments of the external branch elongate. The first exhibits, in a certain position, a hairy bulge near the inner margin. The terminal segment of the endopod is abruptly narrowed from about the middle. The proximal portion exhibits a twisted chitinous border. The endopod is distinctly three-segmented; the segments are so separated from each other, that they remind of the phalanges of a human skeleton. (A result of preserving?)

Left: Second basal with a flap-like extension near the insertion of the endopod. The first segment of the external branch exhibits, in certain positions, a hairy bulge on the basal. The endopod is short, one-segmented,

* Smaller such tooth formations of this type are exhibited by some specimens of *Boeckella lacuna* from Brock's Dam.

and bears at the end a small point. If we take for comparison the Boeckellae described by Smith, *B. rubra* would be suitable for comparison. This is identical with our form in:

(1) the colour.
(2) the tooth-like appendage on the penultimate segment of the gripping antenna and the obiique insertion of the terminal segment of the same.
(3) the structure of the fifth leg of the female, which is conspicuous by the small size of the claw of the middle segment and by the fact that the latter exhibits a faint hair covering instead of the toothing. The claw is not much thicker than the spine of the middle segment, opposite to it.

On the other hand, our form differs from *B. rubra* in the following points:

(1) The distal inner corner of the second basal of the fifth leg of the ♂ does not possess in our form the pointed appendage, typical for *rubra*.
(2) The endopod of this leg is only two-segmented in *B. rubra*, whereas it is distinctly three-segmented in our form.
(3) In the left leg of the ♂ Smith draws, instead of the endopod, a small, hairy appendage, drawn out into a point. In our case, however, there is, besides an appendage of the second basal, a distinctly separated cylindrical endopod, bearing a small point. Furthermore, here the first segment of the external branch is, at the basal portion of the inner margin, bulged and covered with hairs. Even if we assume that Smith may have misunderstood and misinterpreted these formations, by connecting the hairy inner portion of the first segment of the external branch with the endopod, the difference caused by the absence of the extension of the second basal in our form would still remain.

In Fairbridge's table we come (because of the three-sectioned endopod of the right fifth leg of the male) to No. 23. From here because of the lack of a toothed lamella to No. 24, from here because of the shorter thoracic wings to No. 25, where we find the species *saycei* and *propinqua*. Because of the thorn—in our case actually a chitin point in the body wall—on the inner margin of the second basal of the right fifth leg the decision would be in favour of *saycei*; but our species differs from this by the cylindrical form of the endopod of the left leg, which is in our case approximately twice as long as wide, whereas with *saycei* it is not much longer than wide*.

Moreover, the endopod of the right leg is considerably longer than in *saycei*. Whether further details, which can be seen in our figures, e.g., the appearance of the terminal portion of the gripping antenna, could be considered as differences from *saycei*, will only be known after a newer detailed description of the species *saycei* from the *locus classicus*.

B. denticornis was found in sample 15: Little Waterhouse Lake.

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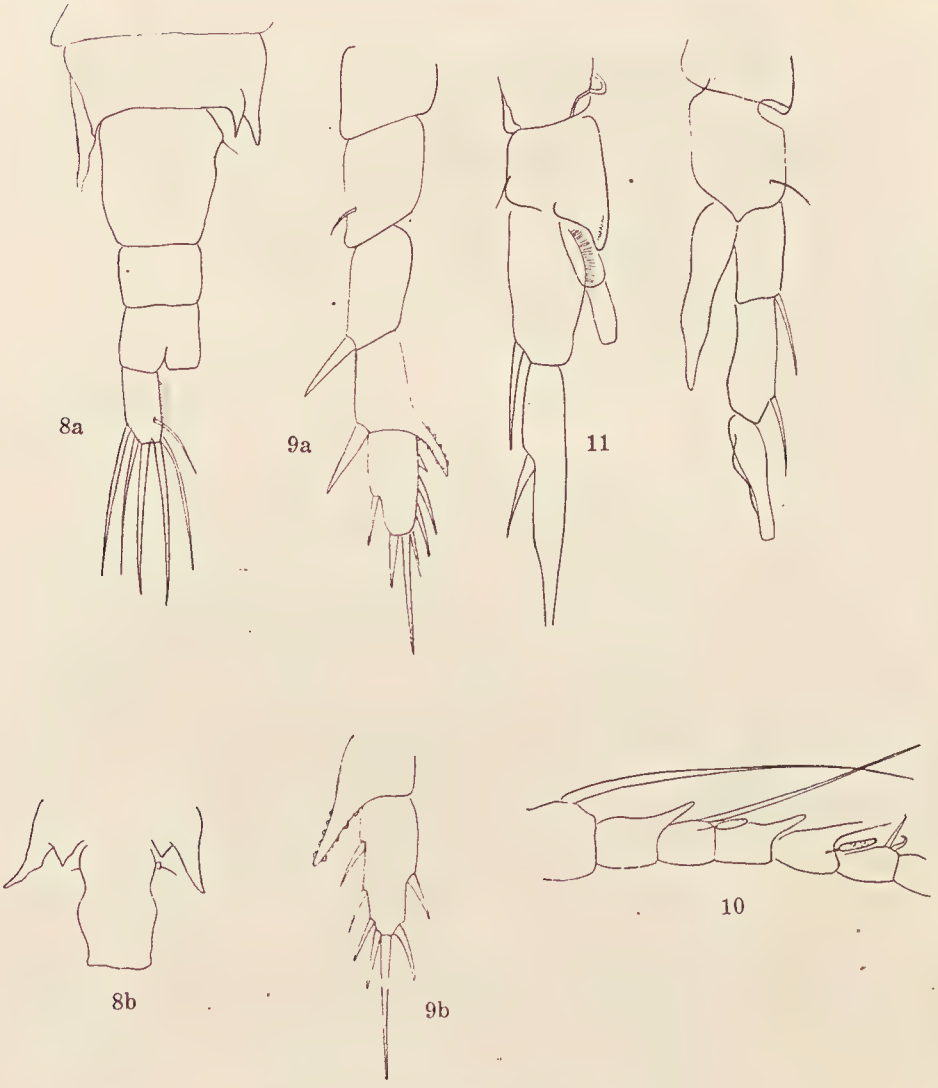
* Moreover, there is a tooth on the inner side of the base of the terminal claw of the left leg. This tooth varies from individual to individual.

Boeckella lacuna Fairbridge, 1945 (Fig. 8-11)



BOECKELLA LACUNA Fairbridge

8a. Female from roadside pond, Tunbridge
8b. Female. End of thorax and genital segment of a specimen from L. Dulverton
9a. Fifth leg, exopod. From Penna Dam
9b. Fifth leg, exopod. From L. Dulverton
10. Spine-like appendages of gripping antenna. From Rostrevor Dam
11. Fifth leg of ♂. From Rostrevor Dam

Although Fairbridge has given an adequate description of the species set up by him, provided with the necessary illustrations, a description based on the material available to me should be given here, in anticipation of the following discussions, since, particularly on account of the question

of the relationship of *Boeckella* from Lake Dulverton, a familiarity with some details is necessary.

Female: length without the furcal bristle 1800 to 2000 μ. The egg sacs of the (mostly pale yellow) animals contain about 25 eggs. The antennulae reach to the end of the furcal bristle. The points of the longer wing sections of the last thoracic segment extend to the middle of the genital segment. The genital segment exhibits mostly two slight lateral swellings of which the proximal one bears a tiny sensory seta. The claw of the middle segment of the exopod of the fifth pair of legs is provided with coarse protuberances. The terminal segment has seven appendages, of which 4 belong to the inner margin. These appendages have the form of medium-sized spines. With some colonies, however, the top one on the outer side is stunted to a short spur, as Fairbridge has mentioned and depicted. Fairbridge also mentions the variability of this structure, which possessed in many of his specimens the shape of a normal spine. This also holds with our material for the specimens originating from Lake Dulverton. Male: Average size: 1650μ. The gripping antenna bears on the 8th and 10th segments two thorn-like appendages of equal and medium length, on the 11th a longer one. The 12th segment is provided with a short spine distal to the sensory seta, the thin end of which is in most specimens curved like the antlers of a chamois (Cf. Fig. 10). Fifth pair of legs: the endopod of the right leg is one-segmented, reaches well up to the second third of the second segment of the external branch. It exhibits two constrictions, which betray the quasi-three-segmented nature of it. The terminal claw has in the basal portion a squat, twisted chitin lamella, which creates two mounds in the contours of the base of the claw. Left leg: at the inner side of the first basal a small semi-circular chitin appendage. At the distal inner corner of the second basal an appendage, bearing plump small teeth, imparting to this formation the look of a mandible. The two-segmented endopod reaches almost to the end of the first segment of the external branch. The first segment of the exopod exhibits at the proximal portion of the inner margin a bulge covered with hair.

Boeckellids corresponding in essence to the characteristics given here, were found in samples 23 (roadside pond near Tunbridge), 24 (Lake Dulverton) and 29 (Rostrevor Dam near Hobart)*. Obviously the form is very frequent in Tasmania and deserves our interest, for it constitutes further evidence for the fact, stated by Prof. G. E. Nicholls, that the fauna in both western and eastern Australia exhibits many common forms, which are lacking in the intervening territory. This fact will not be altered even by the circumstances that Boeckella colonies, which I identify as *lacuna*, do not, in some details, correspond to the type *lacuna*. Even with the present material slight differences were shown, and I cannot state whether they are to be considered as individual, local or temporal variations. However, the occurrence of our form in Lake Dulverton requires a special discussion. From this lake Smith describes the occurrence of but one species of Boeckellid, viz., *Boeckella insignis*. Our sample, however, contains two species, namely a *Brunella* as the far more frequent one and *Boeckella lacuna* as the less frequent one. It is surprising that Smith does not mention the more frequent species and only described a *Boeckella*

* Also in samples from Penna Dam (sample 9) and in the plankton from Brock's Dam (sample 8).

species which, according to his figures, cannot be identical with our species. An explanation of this discrepancy would be possible, I suppose, only on the following two assumptions:

(1) It could be assumed, that since the time of Smith's investigation at the beginning of our century the composition of the plankton of those waters should have changed to such an extent, that the formerly present *Boeckella insignis* should have become extinct and superseded by two other *Boeckellids*; and

(2) It could be assumed, that Smith overlooked the smaller, though more frequent species, or perhaps considered it to be a young stage of the older one, and that his description of *insignis* is faulty, which makes the recognition of the species impossible.

It could be stated in favour of the first assumption, that, according to Smith's account, Lake Dulverton is a shallow basin of water, which is occasionally dry. But even with the assumption that after such a periodical dryness a new "seeding" with other forms from outside should have taken place, it should be borne in mind that such periodical waters with each new filling with water are regularly populated with their own fauna, which springs out of the permanent eggs dried in its mud.

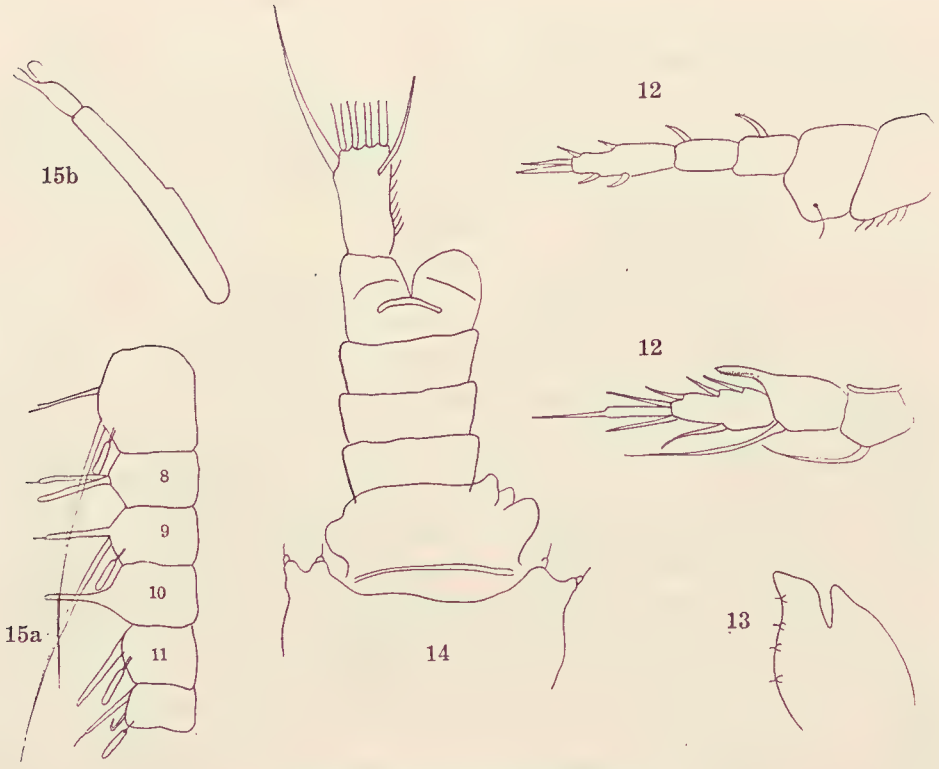
Concerning the second assumption, the fact (weighing against Smith) must be considered, that mistakes made with other species (*Ceriodaphnia hakea*) allow of the possibility, that Smith encountered our form after all, but that his observations and drawings are faulty. In this connection the attention should be particularly drawn to the circumstances of the fifth leg of the male (endopod). Even if we assume that Smith were confronted also with *B. lacuna*, it would hardly be justified to supersede, say for reasons of priority, the name *lacuna* by *insignis*. It will be best to see whether another *Boeckella*, corresponding to Smith's species *insignis* can be found in Tasmania, in which case the designation *insignis* could be retained for this form. Should this expectation not be fulfilled, the name *insignis* should be designated as a *nomen nudum*.

Boeckella pseudocheles Searle 1912 (Figures 12-17)

Although besides two well-preserved males there was but one abdomenless female, I still give a description and drawings of this peculiar species, for the description and figure given in Marsh's synopsis do not suffice to determine whether our form corresponds to the type of this species.

Female: The thorax exhibits a wing, divided into two parts by a deep narrow incision. On the margin of the longer wing point there are four sensory nodules. The small rudimentary leg possesses on the middle segment of the endopod a claw provided with 10 teeth, which grow larger and thicker distally. The terminal segment of the exopod bears seven spines.

Male: 1700 μ long, coloured intensely red. At first sight the gripping antenna appears to have four spine-like appendages. A greater magnification, however, reveals that only—as with other Boeckella—the 8th, 10th and 11th segments are provided with a spine-like appendage. These are of equal length in all three segments (they are longer than the segment is wide) and slender. What appears as a spine-like appendage at the 12th



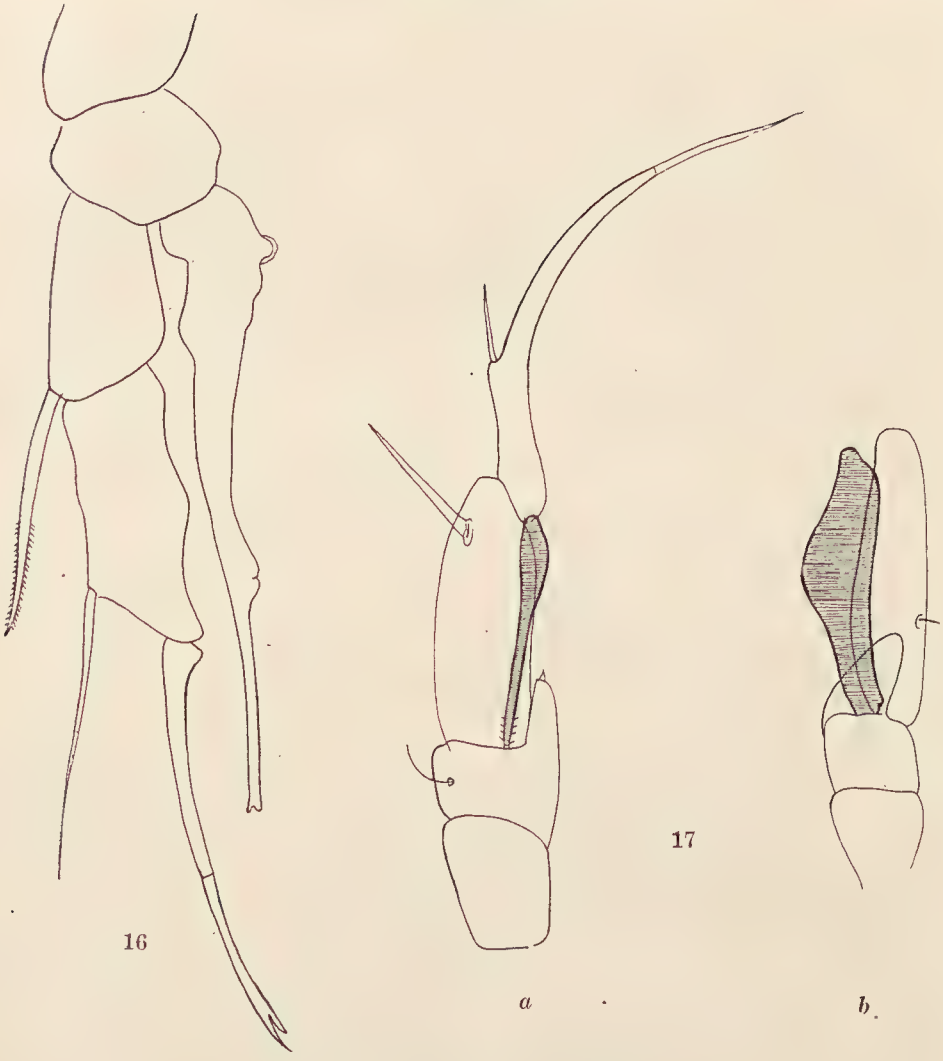
BOECKELLA PSEUDOCHELES Searle

12. Endopod and exopod of the fifth leg of ♀
13. Thoracic wing of ♀
14. Posterior portion of body of ♂
15a. Spine-like appendages of gripping antenna
15b. Terminal portion of gripping antenna

segment is actually a sensory seta resembling a spine-like appendage on account of its thickness and stronger chitinization. Further, the gripping antenna is particularly conspicuous for its last segment but one exhibits a spoon-like extension reaching over the end of the antenna. The thorax is not winged, but exhibits two flaps on either side, each of which possesses a small sensory seta. The genital segment is somewhat asymmetrical, which is due to two small bulges at the distal part of the left side.

Fifth pair of legs: right-hand-side—the endopod extraordinarily long and narrow. The basal portion exhibits a broadening ending with a chitin knob. The end of the endopod is split into two short prongs, reminiscent of the end of the body of a Gordius. Also the terminal claw of the exopod ends like a two-pronged fork with the prongs of unequal length.

Left: the second basal is extended at the terminal inner corner. The endopod, inserted beside this extension, is flattened and looks like a rod, seen from the edge, but leaf-shaped and broadened in the middle when seen frontally. The elongate first segment of the exopod exhibits a sensory knob.



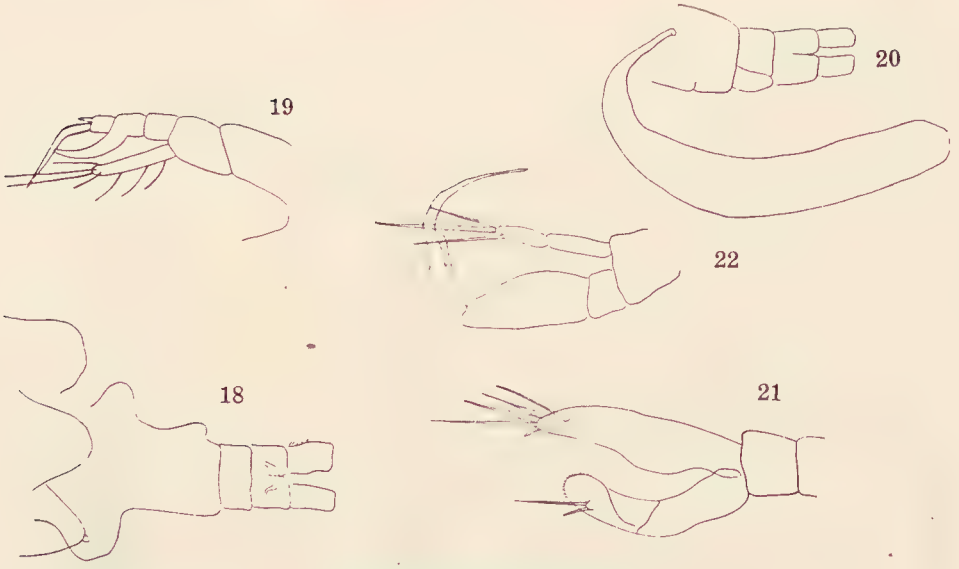
BOECKELLA PSEUDOCHELES Searle

16. Right fifth leg of ♂
17. Left leg of ♂
    (*a*) Endopod edgewise
    (*b*) Frontally

B. pseudocheles occurred as a few specimens in sample No. 19, bearing the designation: "from shallow roadside pond, Waverley Road, Launceston".

Brunella gibbosa n. sp. (Figures 18-22)

Female: 950 μ long without the furcal setae. The antennulae reach beyond the end of the furcal setae. The last thoracic segment broadly rounded, but not elongated into wings. On the genital segment on the left, proximally, a globular appendage, on the right two bulges. The



BRUNELLA GIBBOSA n. sp.

18. Posterior portion of body of ♀
19. Fifth leg of ♀
20. Posterior portion of body of ♀ with spermatophore attached
21. Left fifth leg of ♂
22. Right fifth leg of ♂

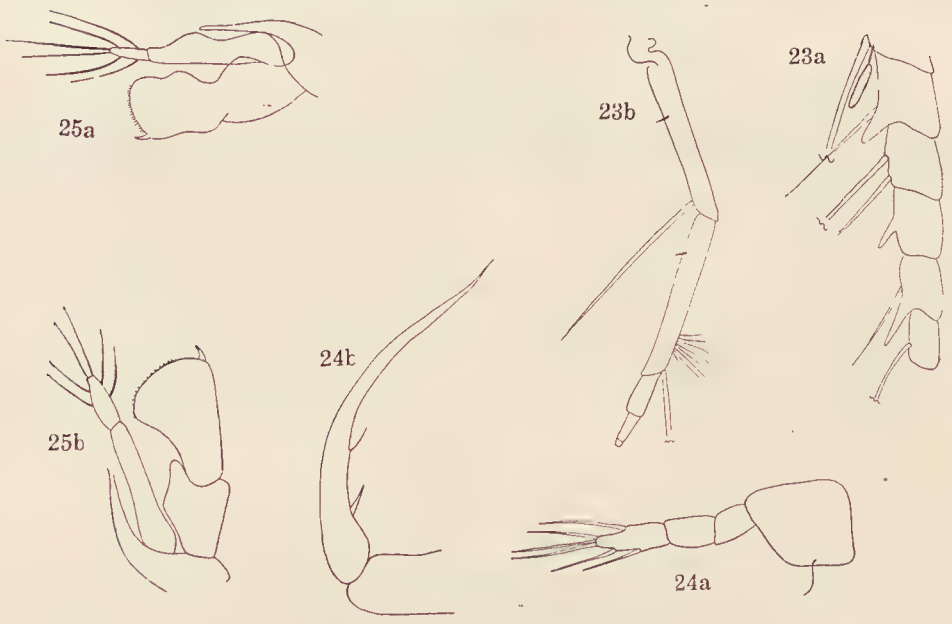
furca twice as long as it is wide, with a fringe of hair on the proximal part of the outer margin. Fifth leg: the second segment of the exopod with a large smooth claw; the end segment with a short spine and a geniculate spine. The inner branch is one-segmented and bears 7 seta-like appendages, of which 4 belong to the inner margin.

Male: 800 μ long. The gripping antenna bears on the 8th segment a spine of medium length, on the 10th and 11th two spines of equal length, larger than those of the 8th segment. Fifth leg: right side: the terminal claw of the outer branch is sinuously bent distal to the insertion of the lateral spine. The inner branch is two-segmented, the terminal segment bears three bristle-like appendages. Left side: The terminal segment of the two-segmented outer branch is extended into a round plate provided with spinules. Above the spinous area one long and one short seta are inserted. The inner branch is one-segmented, longer than the outer branch and armed with a spinule. The large, sausage-shaped and strongly bent spermatophore reaches, when attached to the female genital pore, considerably beyond the furca of the female.

This species, which should be designated *gibbosa* on account of the outgrowth on the genital segment, forms a dominating constituent of the plankton of Lake Dulverton. Since Nicholls (1944) worked out a table for the determination of the genus *Brunella,* two new species, *B. attenuata* and *B. subattenuata* have been described by Fairbridge. Nicholls referred to this fact in a footnote. Since both show a symmetrical genital segment in the female, they are out of the question for the identification of our species and we can, for the purpose of comparison, limit ourselves to the species described by Nicholls. Of these, *B. tasmanica,* first described by

Smith from Tasmania, could be considered first. However, identity with the latter should be highly improbable because of the ecologically different habitat. *B. tasmanica* was discovered in a lagoon separated from the sea only by a sand dune. In fact, there is no resemblance between the two species. By comparison with non-Tasmanian species, using the key set up by Nicholls, we find in the table of females under the species with rounded thorax that our species, on account of the one-segmented endopod of the fifth leg, belongs to the species *ampulla*. This, however, is contradicted by the position of ampulla in the key to the males, for these would also have to exhibit a one-segmented endopod on the right fifth leg, which is not the case. In the key designed for males our form would have to be sought with the last three species of the table, because of the two-segmented endopod of the right fifth leg. The species *expansa* could be considered there, but here again the female exhibits a two-segmented endopod of the fifth leg, this possibility can therefore be discarded and we come, by elimination to the conclusion, that our species is new.

Brunella tasmanica Smith 1909 (Figures 23-25)



BRUNELLA TASMANICA Smith ♂

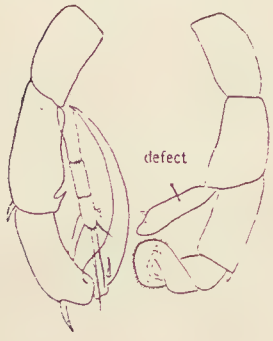
23a. Spine-like appendages
23b. Terminal part of gripping antenna
24a. Endopod of right fifth leg.
24b. Terminal claw of exopod
25. Fifth leg in two different positions

In sample 18 from Big Lake Waterhouse, there were a few male specimens, which I propose to class under Smith's species *tasmanica*, since it tallies in essential points with the description given by Smith. The remaining differences can partly be explained as observational errors, partly as local or individual variations, but chiefly by the fact, that such

complicated formations as the male fifth leg are apt to show, under slight shifts of position, such conspicuous differences in the contours, that differences become apparent, even if not actually present. To supplement Smith's description, attention should be drawn first of all to the structure of the gripping antenna. The 8th and 10th segments bear each a short thorn-like appendage, the 11th segment the same structure of twice the length. The third segment from the end bears a fan, formed of about 8 setae (figures 23, a, b). The terminal claw of the right leg exhibits near the somewhat swollen base a weak lateral spine. Distal to the latter the concave side of the claw forms a prong which bears a delicate sensory seta. The endopod of this leg is provided with 6 setae, whereas Smith drew but 4. The same condition is seen on the terminal segment of the left endopod. The contour of this exhibits, according to the position, either a cylindrical form, as depicted by Smith, or two swellings (figures 25, a, b). The styliform appendage of the second basal on the left as well as the form of the last segment of the external branch of the left leg look characteristically like Smith's figures. The males, 1000 μ long, were olive green with blue extremities.

Brunella expansa Sars 1912 (Figures 26-29)

Sample 17 from Lake Waterhouse containing a *Brunella*, which I propose to classify as belonging to the species *expansa*, in spite of some differences compared with the figures given by Sars. (Copies of these



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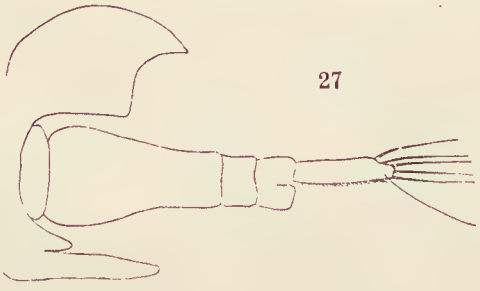

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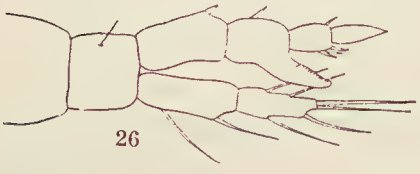

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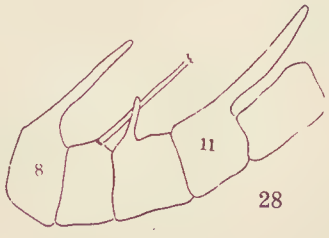

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BRUNELLA EXPANSA Sars

26. Fifth leg of ♀
27. Posterior portion of ♀ ; left wing seen from above, right seen from side
28. Spine-like appendages of gripping antenna
29. Fifth leg of ♂

figures were made available to me through the courtesy of Dr. M. Beier from the Vienna Imperial Museum—I thank him here cordially for it).

The significant differences are as follows: The wings of the last thoracic segment of our form are distinctly broader and clearly bifid, which is particularly visible in the side view (cf. fig. 27 right). The latter feature is perhaps less conspicuous in Sars's figure, because this represents a purely dorsal view. On the fifth leg of the ♀ we find with Sars that the terminal segment of the exopod is on its inner margin beset with delicate setae and terminally with a slender spine, whereas our form is distinguished with shorter, spine-like structures on the inner margin and the terminal spine is shorter and thicker. On the fifth leg of the male, the backwardly directed tooth at the distal inner corner of the first segment of the endopod of the right leg is developed into a pronounced tooth in our specimens, whereas by Sars they are just hinted at. The differences in the structure of the terminal portion of the left leg may be explained as unequally shortened by perspective.

Whether the unusual length of the spinous appendages of the 8th and 11th segments of the gripping antenna, as shown in our figure 28, is stressed by Sars, is beyond my knowledge.

Gladioferens

According to the summary given by Nicholls (1944) so far 5 species of *Gladioferens* are known. Of these, however, only two—*inermis* Nich. and *gracilis* Kief.—are described in such detail, that a comparison is possible. There remain, therefore, some understandable doubts as far as the identification with these species is concerned. Nicholls allows of the possibility that *subsalaria* and *brevicornis* might be identical, and Kiefer* admits the same possibility for *gracilis* and *spinosus*.

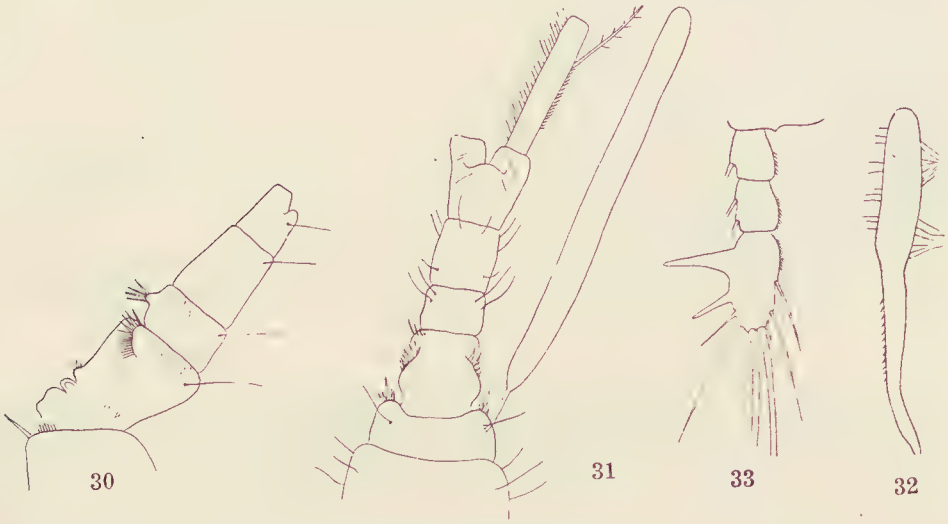
It is quite possible that the genus *Gladioferens* consists of a swarm of microspecies, the separation or partial grouping together of which will only be possible after a renewed investigation of the forms described so far. The question remains therefore open, whether the species described here is to be evalued as a " good species " or not.

Gladioferens henryae n. sp. (Figures 30-37)

Female: Egg-bearing specimens varied considerably in their size about an average of 1700 μ, whereas *gracilis* measures only 1400 μ and *inermis* as little as 1000 μ. The number of eggs is greater throughout than with *gracilis*, namely about 25. The colour is sometimes lighter, sometimes a darker yellow or orange-red. The extremities exhibit, at least at the base, blue coloration. The antennulae reach only to the end of the cephalothorax. The last thoracic segment is simply rounded off and bears terminally a large hyaline spine besides several delicate spinules. The genital segment and the third segment of the abdomen are longer than the other abdominal segments. The genital segment is constricted in the middle on both sides, the anterior half bears on both sides a group of spines, whereas the posterior half bears such a group only on the

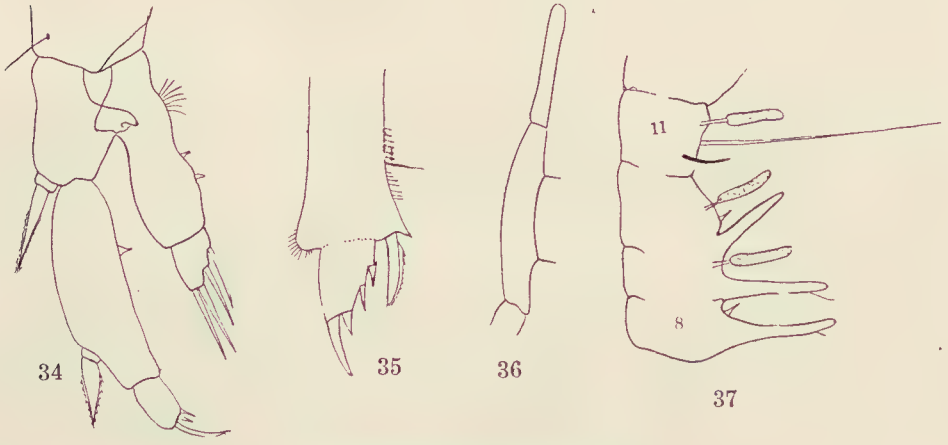
* Kiefer particularly stresses the unreliability of the conditions concerning the segmentation of the extremities; so far, however, just these have formed the key for the determination of the male *Gladioferens* species. For the females the setting-up of a key has not been possible up to the present.

right side. In contrast to the representation given by Kiefer for the species *gracilis*, our form exhibits one long sensory seta at the rear corners on both sides of the genital segment. Such are also present on the thoracic segments. In the lateral view we find areas set with tiny spinules on the genital segment and the segment following it. The furcal branches bear on the inner margin a fringe of long setae, on the outer margin they



GLADIOFERENS HENRYAE n. sp.

30. Abdomen of ♀ laterally
31. Abdomen of ♀ dorsally with spermatophore
32. "Boomerang"
33. Fifth leg of ♀



GLADIOFERENS HENRYA n. sp.

34. Right fifth leg of ♂
35. Left fifth leg of ♂ ; terminal portion of endopod
36. Terminal portion of gripping antenna
37. Spine-like appendages of gripping antenna

are set with tiny spines growing thicker distally, which imparts to this margin the look of the saw of a *Cyclops serrulatus*. The bristle of the outer margin is inserted in the last fourth, in contrast to *gracilis*, where it is inserted in the last third. The " boomerang ", typical for the fourth pair of legs is, in our form, present only in the left leg. It is much broader in the basal half than in the distal half. Again in contrast to the figures given for *gracilis* and *inermis*, it exhibits in the basal part two rows of long setae, whereas the distal part bears one row of short spines. The fifth pair of legs tallies, even in finer details, with the figure given by Kiefer for *gracilis*. Here, too, we find on the inner margin of the first segment of the external branch the small chitin protuberance, also the pointing of the terminal outer corner of the first segment of the endopod and the laterally situated appendage of the second segment of the external branch, which is in our case studded with small spines.

Male: The average length is 1550 μ. The last thoracic segment, which is rounded, bears terminally on both sides a small knob. The furca lacks the armature of the outer margin. The form of the gripping antenna corresponds to the description given for *gracilis*, which should be supplemented by our figure with the considerably bigger sensory cylinder on the middle section. The two teeth, on the margin of the penultimate segment of the antenna, visible in the figure representing *gracilis*, bear each one small sensory hair. The strong lateral spine, characteristic for the second pair of swimming legs, and set perpendicularly to the longitudinal axis of the endopod in *gracilis*, and oriented backward in *inermis*, stands in our form perpendicularly as in *gracilis*. The setae of the inner margin lying distally to this spine are here so modified, that the upper one is transformed into a spine, whilst the one beneath forms something between a spine and a bristle. Nicholls has drawn attention to the systematic value of these appendages, pointing out that with *gracilis* these two bristles are not modified, whereas with *subsalaria* only the upper one is transformed into a spine, so that, consequently, in our case there is a resemblance to *subsalaria*. On the right fifth leg the two short spines near the terminal claw of the end segment of the endopod are, in our form, set quite terminally, whereas in *gracilis* they are inserted further up and *inermis* possesses but one such spine, which is, for that matter, larger and even more proximally situated. Further, with most specimens of our form the chitin appendage on the inner margin of the first segment of the external branch of the right leg was bifid. The conspicuous size of the spermatophore, frequently attached to the female, is visible in figure 31 (Kiefer mentions explicity that no spermatophore were present in *gracilis* and I find no mention of them by Nicholls).

Gladioferens henryae* was present in samples 16, 17 and 18, from Big Lake Waterhouse. Concerning the latter locality the following details are available: " The Waterhouse Lakes (Big and Little) are situated just above sea-level, in sand dune country, near the coast to the north-east of Launceston, about 90 miles distant ".

This statement is interesting with respect to the communications made by Dr. Nicholls in his treatise " A New Calanoid Copepod from Australia " (*Ann. Mag. Nat. Hist.* Vol. 12—1945) on page 514. There he points to the

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* Dedicated to the discoverer of this genus, M. Henry.

fact, that the new genus *Sulcanus*, obviously of marine origin, is always encountered in company with *Gladioferens*, and that *Gladioferens* is typical for waters near shores of variable salt content. The samples from which *Gladioferens henryae* is described here correspond to these statements with respect to the proximity to the shores of the localities in which they were found, but surprise, on the other hand, by the fact, that the accompanying organisms are of a purely freshwater character. It seems that *Gladioferens* already displays a rather outspoken adaptation to pure fresh water.

Red Coloration in Copepoda.

In conjunction with Fairbridge's communication (*Journ. Roy. Soc. West. Austr.* Vol. 29, page 37) concerning red coloration in Boeckellids, I should like to state that I have pointed to the phenomenon of the red coloration of *Boeckella* on the occasion of the description of *Boeckella erubescens**—so called on account of its coloration; a counterpart to the Australian *B. rubra*, also in nomenclature—and that already earlier Father G. Rahm reported in the Monthly Journal for Chile (Year 13) having observed red coloration of *Boeckella* in all lakes of the Andes, from Central Chile down to Patagonia, the temperature of which never rises above 10°. But this coloration would disappear after a few days if he kept them in the lowlands in aquaria. I have discussed the problem of the red coloration somewhat more elaborately than Valkanov in *Biological Reviews* (Vol. 13, 1938), with the result that for the reason or purpose of this phenomenon 11 hypotheses had been set up, none of which enjoyed a satisfactory experimental foundation. Rahm's communications speak for a temperature effect, whereas Fairbridge's cases rather suggest a protection against insolation, as the named author elaborates. Also the conditions prevalent with the present red colony of *Boeckella* from Little Waterhouse Lake speak best in favour of Fairbridge's assumption, since this colony lived in a dune landscape scarcely above sea level. The altitude of the residential waters of the deep-red *Boeckella pseudocheles* correspond to this assumption. Fairbridge mentions the red coloration of *Boeckella opaqua* (described by him) and says in his description: " body, mouthparts and swimming legs are heavily pigmented with red. All colour disappears in a few days on preservation in formalin." It might be mentioned in this connection that when I added formalin to a sample of plankton caught in the Lake Misurina (Tyrolean Dolomites) there occurred an instantaneous change of the colour of the abundantly present *Diaptomus denticornis* into bright blue and that quite generally with certain European Diaptomids the red coloration is supplanted by blue. It may further be mentioned, that the turning of red into blue may occur also in the live animal, but little is known about the reasons and meaning of this colour change. Elster (*Zool. Anz.* Vol. 96) reports that the red specimens of *Diaptomus castor* and *superbus* turn blue with rising temperature, that here, too, the red coloration indicates a lower temperature. With *Heterocope weismanni* of Lake Constance the colour depends on the age, the

* Communications from the research travels of Professor Rahm (*Zool. Anz.* Vol. 112—1935).

young animals being blue. The Heterocopes exhibit the further peculiarity that their vertical migrations become less with the deepening of the blue coloration of the animals. Here again one would suggest protection from light—this time, however, with the blue phase of the pigment. It is certain that, just as the colorations may be based on different pigments, their physiological importance may vary, too. Evidence favouring this statement is found in the above-cited paper of mine from *Biological Reviews*, which I want to supplement briefly here.

Valkanov's assumption, mentioned by Fairbridge, that the red pigmentation might be a result of the mode of nutrition, may be valid with Vampyrellae, which does not mean to imply any statement as to whether the pigmentation is an incidental phenomenon without any consequence or whether a special physiological importance can be attached to it after all.

Valkanov mentions that out of 9 Vampyrellae known so far 8 are pigmented red. The genera *Leptophrys, Protomyxa* and *Hyalodiscus,* related to the Vampyrellae, exhibit red coloration, too. All these organisms are chlorophyll-eaters perforce; they break up the chlorophyll, from which the red pigments are formed. Quite different in nature, however, are the pigments characteristic for the flora of the high-altitude moors and their occurrence in quite different plants in the peculiar environment of the high-altitude moor is certainly not accidental: many sphagnum species, *Sarracenia purpurea,* tentacles of *Drosera,* red sheaths of *Carex caespitosa,* &c. Finally it may be added to by elaborations in *Biol. Reviews,* that Thorid Wulf stressed the vigorous formation of anthocyanins in plants at Spitzbergen and that Palladin contended as early as 1908 that anthocyanin promotes respiration and that colourful foliage is a result of accumulation of respiratory pigments. Now anthocyanin has nothing to do physiologically with the carotin pigmentation of copepods in which we are interested here; but even the carotin pigmentation of animals has been connected with respiration by several zoologists. Evidently we are just as remote from a solution of the problem broached here, as we were in 1938, when I made the above-mentioned report in *Biological Reviews.*

The work on Tasmanian Boeckellae directed my attention once again to the systematics of this genus. I expressed myself earlier to the effect that the characteristics used for the separation of the species offer no basis for the elucidation of phylogenetic relationships. This statement must be corrected in so far as the determination key designed by Fairbridge shows that all the species, of which the exopod of the fifth leg of the female exhibits only three appendages on the end segment, belong to the American fauna, whereas those with more appendages belong to the Old World. Also the circumstance, that the genus *Pseudoboeckella,* apparently separated from *Boeckella* by but insignificant characteristics, inhabits a geographically well defined area, shows that here characteristics, to which one is prone not to attach any particular significance, can be used for the erection of a natural system after all.

A further correction is required by my former statement that Marsh suspected close relationship between the species *occidentalis* (from Peru) and *orientalis* (from Mongolia). It says in Marsh's synopsis, " *Boeckella orientalis* . . . . bears a surprisingly close resemblance to *B. oblonga* found in Australia. It may be a fair question whether the differences should be considered more than varietal. In that case we are faced with the fact that a genus which, with this single exception, is confined to the southern

continents, ... has one species common to southern Australia and Mongolia. This would hardly seem possible and one cannot help conjecturing whether the locality labels . . . . might not have been misplaced ".

Since Marsh wrote these lines it has been found that the understandable distrust of Marsh was not justified after all, as *B. orientalis* for instance has not only been found at its original location, but also at a location very remote from it, in Mongolia. This again raised the question, how is it possible that two almost identical forms of *Boeckella* can occur in Australia on the one hand, and in Mongolia on the other, considering that the numerous species of this genus are otherwise strictly confined to the cooler parts of South America and the Australian Region. Professor G. E. Nicholls devoted his special attention to this problem in his paper: " The Composition and biogeographical relations of the fauna of Western Australia " (*Rep. Austr. Assoc. Adv. Sci.* Vol. 21, 1933), in connection with Serventy's (1929) discovery of a *Daphniopsis* in Western Australia. As generally known, under this generic name those Daphnids have been grouped which, according to Wagler, should be placed within the genus *Daphnia*, but which also embraces a small group of species clustering around the species *tibetana*, represented on the one hand in Central Asia, on the other hand also on Kerguelen Island and on Marion Island and hence exhibit a certain similarity to the Boeckellids as far as geographical distribution is concerned. Nicholls considers the Mongolian Boeckellas to be descendants of the Western Australian Boeckellids, surmising that the Boeckellids originate from the Southern Hemisphere. According to him, the Mongolian colonies would be spearheads of a group of animals domiciled in the far south, advanced far to the north.

The proof of a closer relationship between the Mongolian Boeckella and the Australian species of this genus, stressed by Nicholls, does not contradict the possibility discused by me earlier in the paper: " On the zoogeographical conditions of the circumantarctic freshwater fauna (*Biolog. Reviews*, XI, Cambridge 1936), that Boeckellas, in spite of their present almost exclusive occurrence in the Southern Hemisphere, must have sprung from the North after all, in which case the Mongolian colonies as well as the asiatic forms of *Daphniopsis* could be considered remnant colonies. A decision in favour of either of the two possibilities is, I suppose, hardly possible, for lack of fossil evidence.

HARPACTICOIDA

Delachauxiella

Delachauxiella belongs to those genera which sprang from the Antarctic Continent, while the latter was connected with South America and the Australian Region, but not with Africa*. We therefore find species of this genus in South America, predominantly in the region of the Andes from Patagonia to Peru and then again in the Australian Region. In the latter it has so far been known in the two species from New Zealand, described by me, *D. bennetti* and *D. brehmi*. To these can be

* This is, I suppose, why the two genera *Delachauxiella* and *Chappuisiella* are absent in South Africa, instead of which a species described as *Attheyella* occurs there, (*A. capensis* Ruhe and *warreni* Brady), the exact systematic position of which remains to be elucidated.

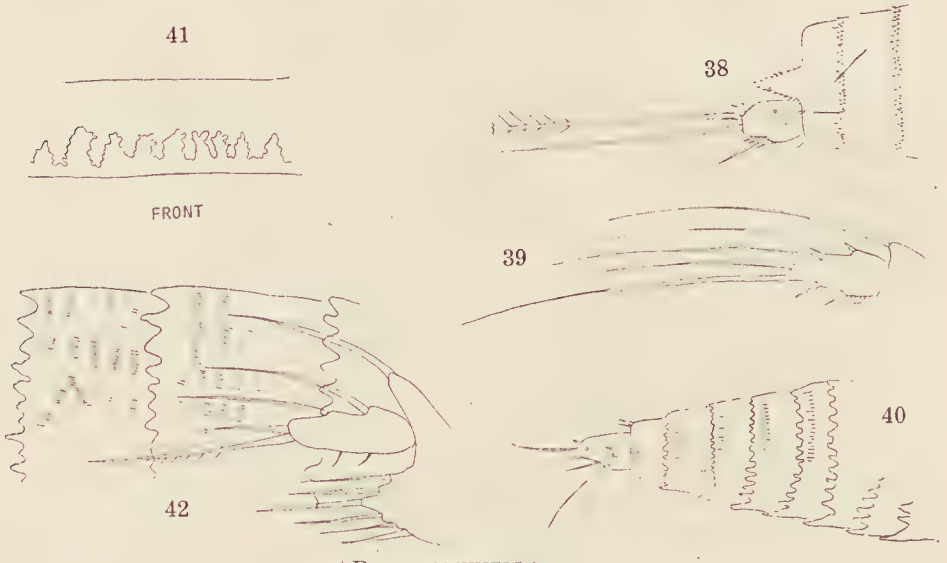
added two Tasmanian species and it can be expected that further such species will be discovered on the Australian Continent, at least in the south-eastern part adjacent to Tasmania.

Delachauxiella salvatoris n. sp. (Figures 40-45)

Female: 800 μ long. Posterior margins of the segments strongly serrated. The teeth are conspicuously large, particularly on the first cephalothoracic segment, the anterior rim of which resembles a wall provided with pinnacles. The margins of the teeth are frequently serrated themselves, exhibiting a corroded look. The number of teeth is 18-20 for each margin, it does not increase as we go forward, since with increasing width of the segments the size of the teeth and their interstices also increases (Figures 40, 41).

Towards the side the teeth grow smaller and above each row of teeth there is a row of short spines. On account of the large size of the median dorsal teeth the animal offers in the lateral view the picture of a scaled animal (*Manis*), cf. Fig. 40.

The operculum is triangular, but of varying aspect, the margin frequently slightly three-lobed, mostly very slightly ciliated, sometimes quite bald. Across its surface one or two rows of fine hairs are apt to run. The furca is about twice as long as it is wide, tapering towards its end and carrying a setose fan on the inner margin. The outer of the two large furcal setae is short (180 μ), the inner one long (700 μ). Figure 43 illustrates the other features of the furca, which are, for that matter,



DELACHAUXIELLA sp.

38. Terminal portion of body of ♀ dorsally
39. Terminal segment of fifth leg of ♀

DELACHAUXIELLA SALVATORIS n. sp.

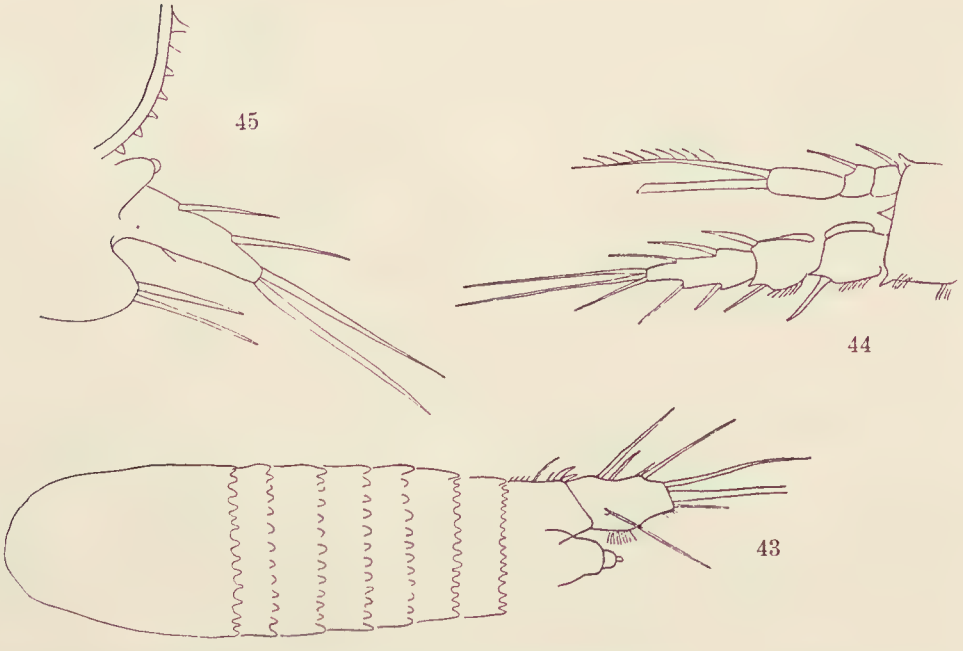
40. Posterior portion of body of ♀ laterally
41. Posterior margin of first cephalothoracic segment
42. Rudimentary leg and ornamentation of abdominal segments of ♀

somewhat variable. The coarse serration of the posterior margins of the thoracic segments as well as the look of the furca and the operculum made me suspect at first that I was confronting Henry's *Moraria longiseta,* which, as already stressed by Chappuis, has nothing to do with the genus *Moraria*. But the armature of the fifth leg alone shows that it is a different form. With Henry's form both basal and terminal segments bear five appendages each, whereas our form possesses six of them on the basal and only four on the terminal segment. The basal segment of the rudimentary leg has six appendages of almost equal size. The second segment is elongate, carries 4 appendages, of which two setae belong to the outer margin; terminally there is a seta of more than twice the length of this segment and beside it one shorter than the segment. No ornamentation on the surface of these two segments could be detected.

In the male the serration of the posterior margins of the segments is not so pronounced as in the female. The inner branch of the third leg bears at the end of the third segment besides a normal seta a pencil-like appendage, cut obliquely at its end. The rudimentary leg has two spines on its basal, and 4 appendages on the terminal segment, of which the two apical ones are almost equally long.

An attempt to include our form in the determination key of Chappuis results in the following arrangement:

9. Furca reaching far beyond operculum 10
   Furca not reaching far beyond operculum 11
10. Furca set with many spines .... *insignis*
    Furca without spines .... *salvatoris*



DELACHAUXIELLA SALVATORIS n. sp.

43. Dorsal view of ♂ 44. Third leg of ♂ 45. Fifth leg of ♂

Found at: Waverley Road, Launceston; Pools in bed of Jordan River; Big Lake Waterhouse.

Since this species was found on the selfsame day on which "Salvator" was tapped again for the first time on the Nockherberg in Munich, I named this new Harpacticoid *salvatoris*, gratefully commemorating precious hours spent there with Munich zoologists.

Delachauxiella incerta n. sp. (Figures 46-48)

Sample 28 (Lagoon of Islands) contained a specimen of a female *Delachauxiella*, unfortunately almost wholly enveloped in filamentous bacteria (*Thiothrix*?), distinguishable from the preceding species at first sight by the shape of the anal operculum. On account of the thick overgrowth with bacteria much—above all the armature of the first four legs— could not be determined with certainty. However, the few certain findings suffice for an adequate characterization. The thoracic and abdominal segments bear coarse teeth on the posterior margin dorsally; on the ventral side they exhibit instead of these one row of strong spines, which is interrupted in the middle with exception of the last row. The furcal branches are conspicuous by their shortness: they are wider than long. Of the two big terminal setae the outer one is very short and delicate. The dorsal seta could only be observed in the lateral position, on account of the disturbing overgrowth. Cf. fig. 47. The anal operculum is triangular with smooth concave lateral margins. The sharply tapering point reaches somewhat beyond the end of the furca. The rudimentary leg exhibits a habit characteristic of the genus: 6 appendages on the basal segment, 4 appendages on the second segment, of which the second from the inside is short and thin. The terminal segment possesses an ornamentation of spines on the surface.

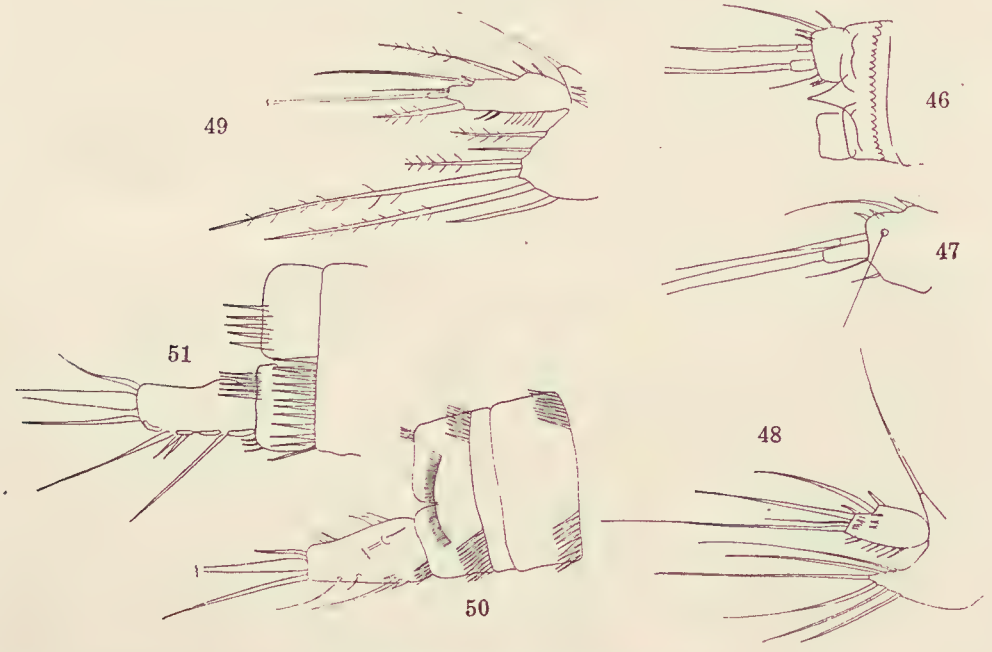
A link with the determination key designed by Chappuis could be established in the following way: The triangular operculum, the furca, not tapering terminally, the unarmed last abdominal segment would lead to number 8. Here we encounter, because of the curved lateral margins of the operculum, the species *maxima*. However, besides the difference in size between this form and ours there are so many differences, that even a remote relationship between the two is out of the question. In *maxima* the operculum is doubly curved, the furca longer than wide and differently armed, the small seta of the second segment of the fifth leg is spine-like, whereas in our form it is developed as a delicate seta and so on. Should, on account of the overgrowth of our specimen with bacteria, the armature of the last abdominal segment have remained unrecognized, we should have to go in Chappuis's table from 7 on to 11, which would take us to the Chilean species *hannae*. But our form has nothing to do with this one either, for *hannae* exhibits straight margins on the operculum, a longer furca, a more prolific surface armature of the fifth leg, to point out only a few differences. A comparison with the species mentioned would, for that matter, hardly be necessary, since they all belong to the fauna of South America, and so far not a single case has been known (the same applies to the Boeckellidae) where a species of the western sector of the circumantarctic region should at the same time be represented in the Australian fauna.

Chappuisiella australica (Sars)*. (Figures 49-55)

I should like to place in this species a Harpacticid from sample 17 (Big Lake Waterhouse), although I am not sure whether the male from the same sample, described further below, belongs at all to the female treated here. In order to decide on the classification into a genus the knowledge of the male is necessary, which alone makes possible the definite separation of the subgenera of *Attheyella*-like Harpacticid. If, based solely on the habit of the female, one decides for a classification to *Chappuisiella* the shape of the anal operculum plays an important part for with *Delachauxiella* this is almost always triangular. Moreover, since a far-reaching coincidence with the habit of the female of *Ch. australica* could be established, I decided not only to classify our form in the genus *Chapuisiella*, but also in the species *australica*. Should, however, the male described below belong to this female, this assumption would have to be revoked.

Female: 830-900 μ long without the furcal seta. Greenish yellow. The posterior margins of the abdominal segments bear on the ventral side a row of very long spines, which is not interrupted in the middle in the two

* Described in 1908 by G. O. Sars as *Attheyella australica* from Victoria.



DELACHAUXIELLA INCERTA n. sp.

46. Terminal portion of body of ♀
47. Lateral view of female furca
48. Fifth leg of ♀

CHAPPUISIELLA AUSTRALICA (Sars)

49. Fifth leg of ♀
50. Posterior portion of ♀
51. Posterior portion, seen ventrally ♀

last segments, but exhibits an interruption in the middle of the preceding segments. The operculum is flat and arched and provided with a hairy fringe on the margin*. The furca is twice as long as wide, with a hairy border on the proximal inner margin. Concerning the other armature, cf. figure 50, where the broken-off dorsal seta is only marked.

The rudimentary leg has 6 appendages on the basal segment, of which the second from the outside is a short thin seta. The terminal segment has 5 appendages, two of which on the outer margin, 3 terminally. The inner margin bears but few hairs and spinules. The outermost terminal seta is short and delicate, more of a hair than a seta. No surface ornamentation was present.

One male, which doubtfully belongs to *Chappuisiella australica.*

As already mentioned, besides the just described female, there was a male, which was at first considered to be the corresponding male, on account of the operculum, which is curved and set with hairs on the margin, an assumption which is however, uncertain because of the fifth leg. This male was but 600 μ long. The spines on the lateral posterior margins of the segments are shorter than in the female. The furca is twice as long as wide; of the two large terminal setae the outer is 400, the inner 600 μ long.

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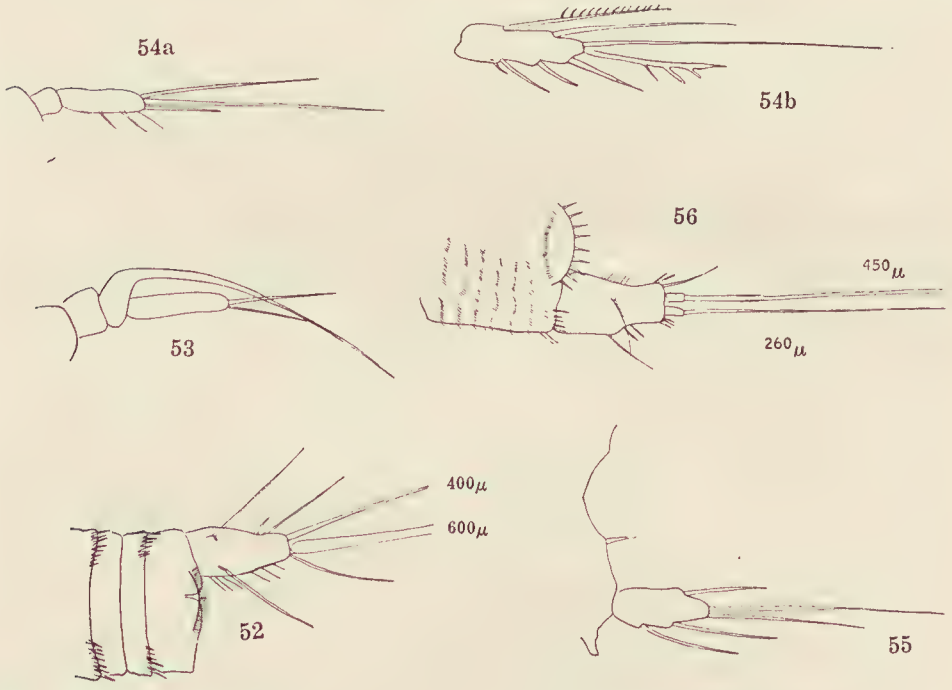
* *A. australica* has an unarmed operculum!



52. Terminal portion of ♂
53. Third leg of ♂
54. Fourth leg of ♂
    (*a*) endopod
    (*b*) exopod
55. Fifth leg of ♂

UNDETERMINED HARPACTICID from sample 21

56. Terminal portion of body of ♀

The beak-shaped outward curvature of the spur on the outer margin of the first segment of the exopod of the third pair of legs is conspicuous. The appendage of the second segment of the endopod of this leg bears no hook at its end. The terminal segment of this endopod bears two setae. The last segment of the exopod of the fourth leg is provided with two appendages. The terminal segment of the exopod of the fourth leg: beside a long, feather-like seta there is a spine, half its length, bearing three* lateral branches, standing off obliquely. This spine resembles very much the homologous formation in *Chappuisiella palustris* Chapp. from Chile, which again makes advisable the classification of this form in *Chappuisiella,* which is already warranted† by the close relationship between the South American and Australian fauna. True, one could object to the classification in the genus *Chappuisiella,* because our form exhibits but one‡ spine on the basal of the fifth leg of the male. This is surprising, for Chappuis in his work on these forms set up the alternative: spine basal or basal with at least two spines, whereby the Elaphoidellae are separated from the Attheyellae. This contrast, however, is mitigated by the fact that Chappuis himself mentions one form, which exhibits a basal with one spine, namely *Elaphoidella cliffordae.*

The second segment of the fifth leg of our form bears five seta-like appendages, of which two belong to the outer margin, one to the inner margin and two are situated terminally. With the small size and concealed way of life of the Harpacticoida, one has been always accustomed to reckon with single accidental findings, when freshwater material is investigated. It was therefore astonishing, when Delachaux described a host of new species from a few samples arising from two locations in Peru. This showed that the waters of the Andes are particularly prolific in Harpacticids, which was corroborated by later investigators.

Considering the far-reaching coincidence of the fauna conditions in the regions situated around Antarctica, it could be expected that in the ecologically similar portions of the Australian Region similar conditions would be encountered. Already my earlier published findings on the fauna of New Zealand demonstrate the justification of this assumption and the present material confirms it anew. For without specially searching after Harpacticoida, four species could be established, of which, however, two could not be identified with certainty.

To be sure, besides the two species described below, two other species were represented by one defective ♀ each, of which one certainly belongs to *Delachauxiella.* It exhibits strongly denticulate posterior margins of the segments and is conspicuous by the fact that the operculum, the tip of which reaches somewhat beyond the end of the furca, possesses deeply tasseled lateral margins. (Fig. 38). The sample came from Big Lake Waterhouse.

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* With *A. australica* there are four branches!

† Kiefer depicts a similar though perhaps more delicate, appendage with *Chappuisiella occulata* Kiefer (Zwei neue Ruderfusskrebse aus Sudamerica. *Zool. Anz.* Bd. 67, 1926).

‡ The missing second spine was not broken off, which was proved by an examination under highest magnication. It remains uncertain, whether it was an accidental variation, for there was but the one specimen.

The other animal certainly did not belong to *Delachauxiella*. Its arched operculum bore only a few long spines. The abdominal segments of the animal, (which is 600 μ long) bore a rich ornamentation in the form of rows of fine spinules. The furca was twice as long as wide and possessed two terminal setae, of which the outer one measured 260, the inner 450μ. Cf. fig. 56.

Cyclopidae

Since Smith describes but two species of Cyclopidae from Tasmania and introduces both as new species, one might suspect that, although Tasmania is poor in Cyclopidae, it excels in a highly developed endemism of this group. However, both assumptions are incorrect. For, although our communications can only enumerate six species, it must be borne in mind, that besides these the present samples contained several stages of Cyclopidae, which certainly did not belong to the species mentioned here, the relationship of which, however, could not be determined. As for the endemisms, it should be noted that one of Smith's two species *albicans* was recognised by Kiefer as being identical with the species *Mesocyclops leuckarti,* whereas the other *dulvertonensis* is probably nothing else but *leuckarti* either, for in the plankton from Lake Dulverton, from which Smith described this form, nothing else could be found, than just *leuckarti.* Or else, the fauna of this lake must have suffered a change since Smith's time (as discussed more fully on page 39) and Smith's species might be discovered in Tasmania later. Of our species *leuckarti, albidus* and *phaleratus* are cosmopolitan, *crassicaudoides* seems to be confined to the Australian Region, but not to Tasmania, since it was discovered in New Zealand; and the two *Eucyclops* species will certainly still be discovered at least in south-eastern Australia.

Macrocyclops albidus Jur.* is rather frequent in samples 21, 25 and 23 (Cleveland Lagoon; Roadside pond, Tunbridge; pools in bed of Jordan River).

Mesocyclops leuckarti Claus.* Present in almost all samples of plankton, obviously the most frequent Cyclops of the island (cf. fig. 65).

Ectocyclops phaleratus Koch. With regard to the occurrence of very similar species in Africa it should be pointed out that the specimens from Tasmania exhibited a median spine on the endopod of the fourth leg, twice as long as the limb itself, that it is consequently the typical species which had also been reported from the Australian Continent. Occurred in sample 25 only (Pools in bed of Jordan River).

Diacyclops crassicaudoides Kief. was found only as a female, 850 μ long, the egg sacs of which contained 18 eggs each, in sample 19 (Waverley Road, Launceston). According to Kiefer, *D. crassicaudoides* is a fine example of the fact that even Cyclopidae can be used in zoogeography, when the picture of the geographical distribution, more veiled than elucidated by earlier investigations, is to some extent cleared.

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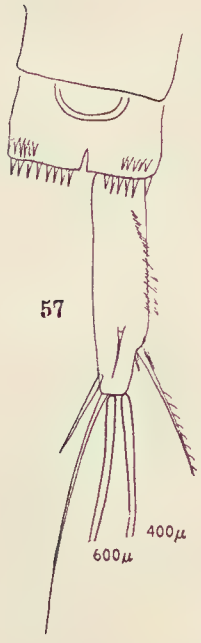
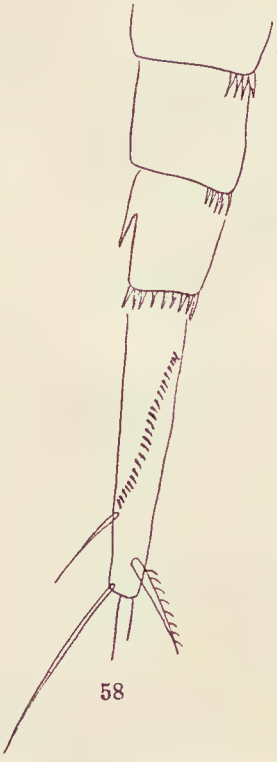
* The two species *albidus* and *leuckarti* seem to be the most frequent and most widely distributed Cyclops in Australia. For Lindberg, too, mentions in his description of *Eucyclops linderi*: " L'echantillon renfermait aussi, *Macrocyclops albidus* et *Mesocyclops leuckarti.*"

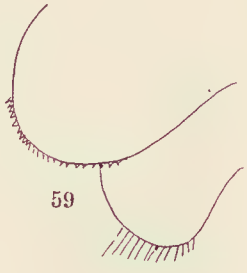
Eucyclops nichollsi n. sp. (Figures 57-64)

There were a few specimens of a *Eucyclops* of both sexes from Cleveland Lagoon and Big Lake Waterhouse as well as from pools in the bed of the Jordan River. These could not be identified with any of the known species and did not exhibit any closer relationship to the known species *Eucyclops linderi* from Australia.

Female: egg-bearing females—one egg sac contained about 20 eggs—reach a length of 1200μ. These were light yellow, the genital segment was coloured brown-orange. The terminal segment of the 12-segmented antennule bears a quite narrow, not toothed hyaline membrane. The posterior margins of the abdominal segments are without armature on the dorsal part, and on the ventral side they show a row of spines. The furca is about 4 to 5 times as long as wide, possesses a hairless inner margin and on the outer margin a saw, formed of long strong teeth, beginning at the uppermost fifth of the furca and ending in an obliquely running spiral at the last fifth of the furca. Since the teeth do not lie in a plane, they create the impression as though they increased considerably in size distally. The outer one of the two large terminal setae is 400 μ,







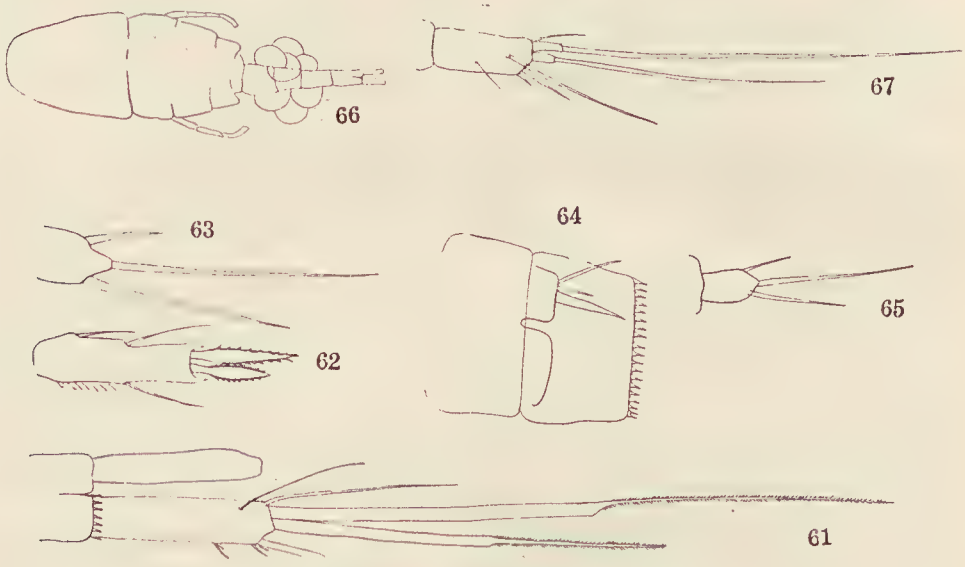
EUCYCLOPS NICHOLLSI n. sp.

57. Terminal portion of body of ♀
58. Furca of ♀ laterally
59. Terminal portion of thorax of ♀
60. Intermediate plate of fourth pair of legs

the inner one 600 μ long. The last thoracic segment is haired on the margin, the last but one exhibits on the margin a fine denticulation, visible only under high magnification. The receptaculum was not so clearly visible that its shape could be described. The intermediate plate of the fourth pair of legs exhibits at its inner part on either side five spines oriented obliquely inward. The inner spine of the terminal segment of the exopod of the fourth leg is one third longer than the outer spine. The rudimentary leg possesses a median spine, hardly wider than the adjacent seta*.

Male: Considerably smaller than the female, with a sawless furca. The spine of the outer margin of the furca is cylindrical and at the end abruptly pointed, like a pointed pencil. The two large terminal setae consist of two sharply separated portions. The basal portion is wide, cylindrical and smooth, about 2/3 of the length of the whole seta. The distal third consists of a much thinner seta, densely plumose. On the genital lappet there was innermost a spine of about the length of the segment, then a small seta about half that length and outermost again a seta. If one attempts to determine this form with the key designed by Kiefer in "Das Tierreich", the 12-segmented antennule with the sawless terminal section, the appendages of the fifth leg, the bare inner margins of the furca and the length of the saw of the furca lead to number 12. The species *semiserratus* and *speratus* which occur there are

* There was, however, one ♀, with which this spine was double the width of the seta.



EUCYCLOPS NICHOLLSI n. sp.

61. Posterior portion of body of ♂ ; dorsally
62. Terminal segment of endopod of 4th leg, ♂
63. Armature of terminal segment of 5th leg, ♂
64. Armature of male genital lappet

EUCYCLOPS MISER n. sp.

65. Rudimentary leg, terminal segment
66. Habit of ♀
67. Furcal branch, dorsally

out of the question on account of the length of the furca, and the latter also on account of the coarser serration of the saw. If our form were allocated to those species having a furca of medium length, the only possibility would be *van douwei* from Kameroon, which, however, differs in shape of the fourth and fifth legs.

Eucyclops speratus n. var. tasmanica

Sample 25 (pools in bed of Jordan River) contained some yellow females, 1200 μ long, with greyish-blue egg sacs which, on account of their numerous (about 50), extremely short teeth on the furca suggested their belonging to the species *speratus*. The terminal segment of the 12-segmented antennule bore a narrow, unserrated, hyaline membrane. The rudimentary leg entirely corresponds to the structure of the typical *serrulatus*. The length of the furcal branches was six times their width. The form differed from the typical *speratus* by the fact that in the latter the furcal saw extends only over half the length of the furca, whereas here (in our form) it was 5/6 of it. Whether there are further differences, remains undecided, because I had no comparison material of *speratus*. But since *speratus* so far has only been found in the Northern Hemisphere, the existence of such differences is likely and it is well justified to discriminate our form from the type as "*var. tasmanica*", if only with regard to the length of the furcal saw.

Eucyclops miser n. sp. (Figures 65-67)

Sample 21 from Cleveland Lagoon contained not infrequently a Cyclops, the egg-bearing females of which were but 600 μ long. I first believed it was a *Microcyclops*, just as Kiefer reports for the *Eucyclops indicus*, described by him. Then I suspected the latter, when I recognized a *Eucyclops* by its rudimentary leg.

But already the much longer antennules revealed that it was not identical with *indicus*, described from Himalaya. Then *Eucyclops linderi*, from Australia, occurred to me as an object for comparison. A description of our form should precede the comparison between the two mentioned species.

The picture of the habit of the ♀ (figure 66) shows a long, slender abdomen. The terminal thoracic segment bears no fringe of spines or hairs, as *Eucyclops* species frequently do.

The receptaculum was not recognizable. The 12-segmented antennule reaches beyond the end of the thorax. Its terminal segment is slightly curved inward. The egg sacs consist of but few big eggs, mostly four on each side. The furca is two and a half times as long as wide. Its armature is shown in figure 67. The median spine of the rudimentary leg is hardly thicker than the two setae of the leg.

If our form is compared with other species of *Eucyclops* those among the sawless species can be eliminated, which can be distinguished by their considerably longer furca. Those are, apart from the troglobiontic forms *graeteri* and *teras*, African throughout. A shorter furca is found in *indicus* and *linderi*. The first species, described from Himalaya, differs from ours already by its much shorter antennule. In the second species, too, the antennule is considerably shorter. The latter species is better suited for comparison, because it belongs to the Australian fauna. Besides, our form differs by the slenderness of the median spine of the fifth leg, by the ratio

in the length of the most median and most lateral furcal setae and by the seta on the outer margin of the furca, which is inserted higher up.

♂ were not found. The ♀ were colourless.

On account of its small size the new species may be described as the " inconspicuous " *miser*.

Only *E. indicus* with its length of 500 μ is smaller than this.

A survey of this list demonstrates two conspicuous phenomena: (1) None of the Boeckellas found by Smith was found again—if we discard the possibility of an identity between *Boeckella lacuna* and Smith's *insignis*; apart from this questionable case all the Boeckellas collected by Nicholls were new for Tasmania. (2) The abundance of Calanoids in the island is surprising. This abundance can only be conceived if the Calanoida fauna of Tasmania is compared with that of a similar equally large territory on another Continent. Bohemia in Europe would be about the same size as Tasmania. Now whereas Bohemia (apart from the sporadic and transient occurrence of *Heterocope saliens*) is inhabited by only one single genus of Calanoids—*Diaptomus*—which is there represented by two* species *castor* and *vulgaris*, Tasmanian exhibits three genera with about a dozen species! Even if among these, as discussed with *Boeckella lacuna*, there should be synonyms, the number still remains surprisingly large, all the more as further investigations are likely to reveal in Tasmania other species, so far limited to and known from southern Australia. This abundance of species is, however, by no means a special case valid only for

Survey of the Tasmanian Copepoda known so far

	I	II	Occurrence outside Tasmania
Macrocyclops albidus Jur.	—	+	Cosmopolitan
Mesocyclops leuckarti Claus (= *albicans* Smith)	+	+	Cosmopolitan
Mesocyclops dulvertonensis Smith = *leuckarti?*	+	—	Cosmopolitan
Ectocyclops phaleratus Koch	—	+	Cosmopolitan
Diacyclops crassicaudoides Kief.	—	+	New Zealand
Eucyclops nichollsi n. sp.	—	+	—
Eucyclops speratus var. *tasmanica*	—	+	—
Delachauxiella salvatoris n. sp.	—	+	—
Delachauxiella incerta n. sp.	—	+	—
Chappuisiella australica (Sars).	—	+	Victoria
Gladioferens henryae n. sp.	—	+	The genus has so far been known from Australia and New Zealand. New for Tasmania
Brunella gibbosa n. sp.	—	+	—
Brunella tasmanica Smith	+	+	—
Brunella expansa Sars	—	+	Victoria
Boeckella robusta Sars	+	—	South Australia
Boeckella rubra Smith	+	—	—
Boeckella longisetosa Smith	+	—	—
Boeckella insignis Smith	+	—	—
Boeckella lacuna Fairbr. (= *insignis*?)	—	+	Western Australia
Boeckella pseudocheles Searle	—	+	Victoria
Boeckella denticornis n. sp.	—	+	related to *saycei* from South Australia

* A third species *denticornis* has recently become extinct.

Tasmania, but is connected with the great abundance of Calanoids in Australia at large, which is duplicated in Tasmania, as this island represents a piece of land, separated only in recent times from Australia, and offering suitable living places to numerous Calanoids through its hydrogeographical conditions.

Appendix

Among the material obtained from Dr. Nicholls there were also some samples from Western Australia. These, however, contained only two already known species, namely:

Boeckella pellucida Fairbr. from Kalgoorlie and from the same source the species described recently by Lindberg as *Cyclops restrictus* and recognized by the same author as synonymous with *Microcyclops sydneyensis*, which has been classified by Kiefer as *Microcyclops australis*. Lindberg's specimens, too, came from Kalgoorlie, whereas the earlier authors obtained theirs from the environments of Sydney.

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Pap. & Proc. Roy. Soc. Tasmania, Vol. 87 (15th August, 1953)

Contributions to the Freshwater Microfauna of Tasmania

Part 2—Daphnidae, Bosminidae, Cytheridae, &c.

By

Dr. Vincenz Brehm

Biological Station, Lunz, Austrian Academy of Science

WITH 11 TEXT FIGURES

The second part of this treatise was to deal with the Cladocera and Ostracoda. Since supplementary material as well as some rather inaccessible literature should be first secured for the elucidation of some doubtful cases, the report will now comprise only the Daphnidae, Bosminidae, Cytheridae and the genus *Dunhevedia;* the Ostracoda and Cladocera are to follow later. Further two communications on larvae of Diptera may find room in this communication. The work on the few Hydracarinae, completed in the meantime by courtesy of Dr. Szalay, Budapest, may be inserted. Dr. Hunstedt is at present occupied with the survey of the Diatomeae.

CLADOCERA

Communications by Henry and Smith reveal the lack in Tasmania of the families of Sididae, Holopediidae, Leptodoridae and Polyphemidae. This cannot surprise, since they have also remained foreign to the Australian Continent, except for two Sidides—*Latonopsis australis* and *Diaphanosoma excisum*—which are advancing from their tropical homelands into Queensland.

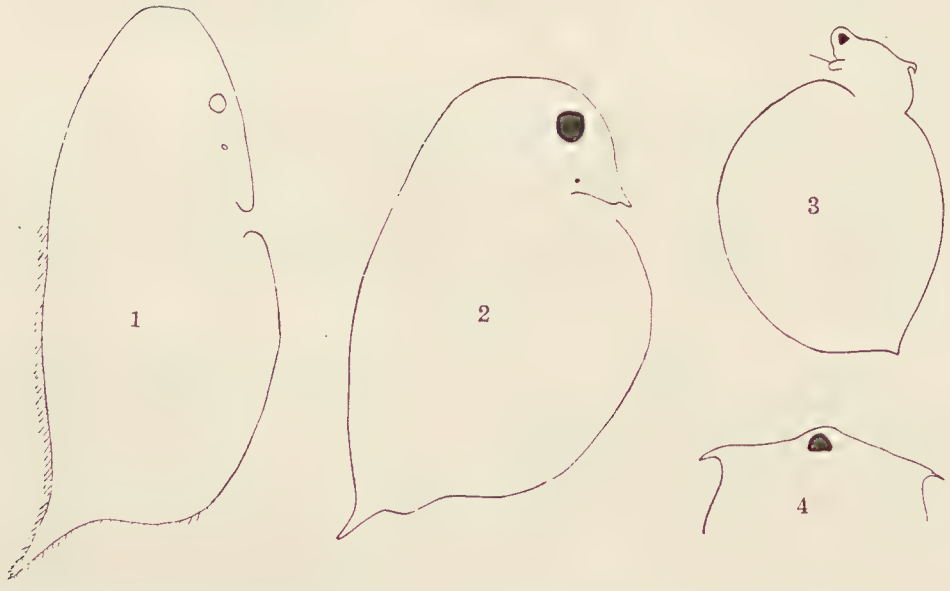
Daphnidae

Whereas Henry mentions 8 Daphnidae from the Australian fauna, Smith enumerates for Tasmania only the species *carinata,* the occurrence of which is designated " cart rut near Plenty ".

The many Daphnidae mentioned by Henry might all belong within the groups of forms of the variable *D. carinata,* with the exception of *D. lumholtzi,* cited from Queensland. For Wagler is right in saying in his paper " The systematic and geographical distribution of the genus Daphnia " (*Arch. f. Hydrobiol.* Vol. 30, 1936, page 525) : " Gegen die Einordnung der Formen *gravis, magniceps, expansa, lamellata* in die species *carinata* wird kaum Widerspruch erhoben werden."

Since for climatic reasons the occurrence of the almost tropical *lumholtzi* can hardly be expected in Tasmania, the Tasmanian fauna of Daphnids will be limited to the species *carinata*. This was contained in the following samples:—

15. Little Lake Waterhouse. The young animals present in this sample exhibited (cf. fig. 1) the formation of a helmet of the type described by me earlier in a colony from the Sunda Archipelago (Die Cladoceren der Deutschen Limnol. Sunda Expedition, page 659).
23. Roadside pond, Tunbridge; and
29. Rostrevor Dam. Besides specimens of normal habit of the head, this sample contained also specimens with which the head was flattened. By this they approach forms (mostly with specific names) of the warmer parts of the Australian Region, without, however, reaching such excessive shapes as *cephalata*, &c. Our fig. 2 represents one such female with an ephippium, possessing a spineless body 3500 μ long. The ephippium contains two obliquely set rows of eggs. The larger proximally situated part of the processus abdominalis is bare, the two smaller distal ones are haired. Since Haberer suspected earlier that the excessive formations of *cephalata* might be monstrosities caused by fungus infection, it should be noted that the present form revealed not even a trace of a fungus infection.



1. Helmeted young form of *Daphnia carinata* King.
2. Ephippial female of *Daphnia carinata*. Form approaching *D. cephalata*.
3. *Ceriodaphnia quadrangula*, described as *C. hakea*.
4. Dorsal view of head of "*Ceriodaphnia hakea*".

Since Nicholls was recently able to refer to a representative of the *tibetana* group of Daphnid species (earlier known as *Daphniopsis*), in Western Australia, it was to be watched whether a form belonging here did not occur in Tasmania too. But none was present. However, a sample from Western Australia contained a colony of *carinata*, the samples of which—partheno females throughout—exhibited a length of 3400 μ, of which the spina measured 700 μ. The abreptor of these animals exhibited conspicuously strong spinules in transverse rows.

Ceriodaphnia

Henry notes the following species of this genus from Australia: *rotunda, cornuta, spinata, sublaevis*. Smith mentions none of these species from Tasmania, but describes two new ones under the names *planifrons* and *hakea*, the first from Lake Sorell, the second from Lake St. Clair.

However, this apparent great abundance of *Ceriodaphnia* in the Australian Region has been recognised as incorrect by investigations carried out since Wagler has shown for the European fauna that the species *hamata, connectens, intermedia, affinis* and *pulchella* are nothing else but forms of the cosmopolitan species *quadrangula*. It will probably be similar with most Australian " species ". There is one more thing. The species *hakea* was, as we shall see presently, set up by Smith as the result of a misunderstanding. Dr. Nicholls also procured for me a sample of plankton from Lake St. Clair, which showed that Smith's allegation: " The head bears dorsally a remarkable recurved hook, a character not known in any other member of this genus ", must be a result of the fact, that Smith considered as an outgrowth of the head the points of the fornix, which in a lateral position of the animal present themselves as Smith depicted them (fig. 3). Had he seen a specimen of this *Ceriodaphnia* in a dorsal, or ventral view, he could not have missed the fact, that the alleged outgrowth is present twice and belongs to the two fornices (fig. 4). *Ceriodaphnia lakea* is nothing else but a form of *quadrangula*. Concerning the species *planifrons* I again suspect that it is not a new species, but, having no material from Lake Sorell at my disposal, I wish to leave this question open. That *planifrons* is no new species, is made even more probable by the fact that all *Ceriodaphnia* in Nicholls's material belonged to the species *quadrangula*. This species was present from the following localities:—

4. Lake Dobson.
8. Brock's Dam. These animals have a short spina set in the median.
19. Pond, Waverley Road, Launceston. The spina of this colony is set more dorsally (fig. 5).
30. Lake Leake near weir. This colony differs from all others by the excessively large main eye (fig. 6). Maybe the rows of setules on the proximal part of the abreptor are better formed than with other colonies. These differences, however, are not sufficient for a specific separation of the mentioned *Ceriodaphnia* colonies of Tasmania.

Simocephalus

Of the five species of this genus, which Henry described from Australia, Smith mentions but one from Tasmania: *australiensis*; he further described a new species from Lake Dulverton, *S. dulvertonensis.* Before we turn to the species found by Nicholls, I must return once more to Smith's *Simocephalus dulvertonensis,* which has already been the object of two treatises, namely:—

BREHM, V.—Cladocern aus Neu-Seeland. *Arch. f. Hydrobiol.* Vol. 23, 1931; and

BREHM, V.—Uber *Simocephalus dulvertonensis* Smith. *Zool. Anz. Vol.* 140, 1942.

In the former treatise I pointed to the flaws in Smith's description, of which he himself claims that it " does not offer any marked characters ".

I further mentioned that a form, which I obtained from New Zealand, might be identical with Smith's, if that latter also possessed the geniculate anal setae which are characteristic for the New Zealand animals. I expected the decision from a subsequent investigation with animals from Lake Dulverton. In the second above-mentioned treatise I pointed out that the shape of the anal setae, which I intend to use as a characteristic feature for the species *dulvertonensis,* is also characteristic for *Simocephalus corniger* from South Africa, described by Methuen (Methuen, P. A.: On a collection of Freshwater Crustacea from the Transvaal. *Proc. Zool.*

5. *Ceriodaphnia quadrangula* from Waverley Road Pond.
6. *Ceriodaphnia quadrangula* from Lake Leake.
7. *Bosmina hagmanni* from Lake St. Clair.
Young forms with dorsal incisions on the mucro.
Abreptor of a mature animal is drawn into the interior.

Soc. London 1910). Unfortunately the description given by Methuen is also so incomplete, that no decision can be made. This, however, would be necessary in order to fix the correct names for the species, for Methuen's designation *corniger* should have priority.

Since the forms in question, *dulvertonensis* and *corniger* as well as the mentioned form from New Zealand hardly correspond to a "good" species, but presumably fall into the frame of the rather polymorphous species *Simocephalus vetula**, I would not have come back to the problem broached here, if material from Lake Dulverton had not been made available to me, which would be expected to allow of a solution of the problem set above.

Unfortunately, the discrepancy discussed already in our report on Copepoda between Smith's and my own investigations of the material from the same lake, again arises. Nicholls's sample, very abundant in Crustacea, did not contain any specimens of *Simocephalus* and so the *pium desideratum* from the year 1931 still remains. Moreover, the opinion expressed already in the report on Copepoda, that the composition of the fauna of Lake Dulverton might have changed since the time of Smith, becomes more likely. We must therefore limit ourselves to the characterization of the species found.

Simocephalus australiensis Dana

In this species—provided it should not be classified as *exspinosus*—I propose to put the animals from sample 31† since they exhibited on the terminal claw of the abreptor a strong side comb, possessed a point-shaped side-eye and also coincided in the contour of the shell and the shape of the head with the picture given for our form by Henry. Our form, however, differs from Smith's representation, for his statement concerning the shape of the head (he speaks of a "distinct projection on the underside of the head") does not correspond to our colony.

Simocephalus vetula O.F.M.

The specimens from sample 28 (Lagoon of Islands) resembled *australiensis* in the shape of the head and the contour of the shell, but must be placed in the species *vetula* on account of the line-shaped side-eye and the fact that the terminal claw lacked a side comb. Females bearing embryos were 2600 μ long.

Simocephalus sp.

The animals from sample 23 (Roadside pond South of Tunbridge) resembled again *australis* in the shape of the body, but the terminal claw possessed no side comb and the side-eye was point-shaped. Abreptor with 12 anal spines. It is obviously a colony of *vetula*, deviating from the type by the side-eye.

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* Even the most recent literature uses time and again *vetulus*. I wish, therefore, to stress, that the name of the species is *vetula*. Vetula = old woman is substantive.

† Roadside pond near Mathinna.

Bosminidae

Bosmina

It is very surprising that Henry mentions this genus from New South Wales only, whereas Smith noted as many as three species from Tasmania, all of which were described as new. They are *B. rotunda* from Lake St. Clair, *B. brevirostris* Great Lake and *B. sorelli* from Lake Sorell. These three alleged new species have already been the object of criticism by Rühe, who says in his paper: " Bosmina coregoni " (*Zoologica*, Vol. 63, 1912, page 14) : Beschreibung und Zeichnung dieser Arten sind völlig unbrauchbar und nichtssagend, so dass mit denselben absolut nichts anzufangen ist ". How right Rühe was, follows from a subsequent investigation of a sample of plankton from Lake St. Clair, which, according to Smith, was to contain *B. rotunda*. Of this as well as of the two others also described by him as new species, he says: " they are closely related to the common northern *B. longirostris* ". This would be quite possible with respect to the occurrence of this species in New South Wales, claimed by Henry. The present plankton from Lake St. Clair, however, shows that the *Bosmina* of this lake has nothing to do with the species *longirostris*, but belongs to the groups of forms *Bosmina hagmanni*, so frequent in the Southern Hemisphere. The determination was rendered difficult—as with many colonies of this species in the lakes of the Andes in South America—by the fact, that not only with older animals, but also with young animals the mucro bore no incisions. Only after a survey of numerous very young specimens we succeeded in finding two pieces which exhibited so distinctly the shift of the incisions of the dorsal part of the mucro, so characteristic for *hagmanni* (cf. fig. 7).

I suspect that the two other species described by Smith are nothing else but *B. hagmanni*. This conjecture is rendered even more probable by the fact that the plankton from sample 21 (Cleveland Lagoon) contained a *Bosmina* too, which certainly did not belong to the species *longirostris*. The distal position of the seta on the forehead, the erect posture of the antennule and the armature of the terminal claw of the abreptor tally with the conditions in *Bosmina* from Lake St. Clair. On account of these facts, I propose to relate this form to *hagmanni*. Unfortunately, the certain proof through the dorsal incision of the mucro could not be obtained, for lack of young animals. Neither here nor in Lake St. Clair was it possible to find males, or females with permanent eggs.

Chydoridae

Dunhevedia crassa King

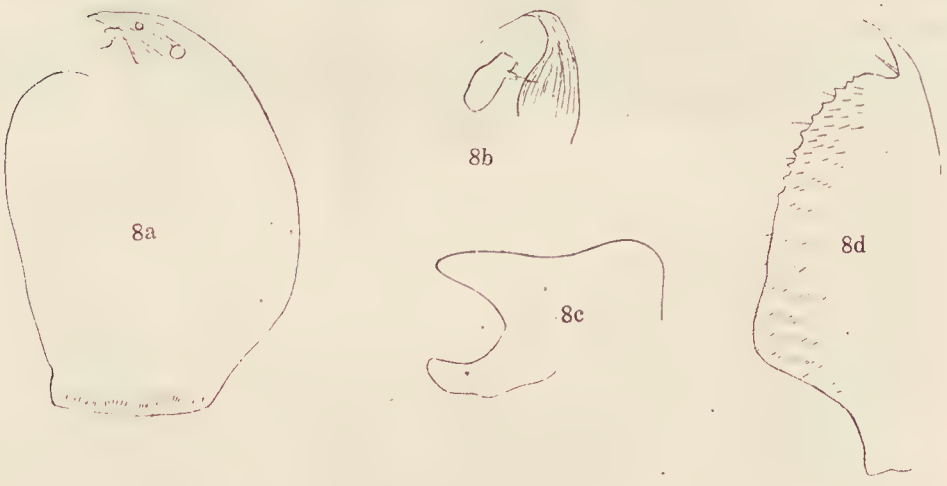
Whereas Henry mentions two species of this genus from the Australian Continent* of which the one, *podagra* King, is very problematic, Smith does not mention any occurrence in Tasmania of this ill-described Cladoceran. As a result, it is new for Tasmania, and seems to be rather infrequent there, for it was detected in but one sample, in T. 19 (= Pond, Waverley Road, Launceston).

* King mentions *D. podagra* from Parramatta. Henry found *D. crassa* in Queensland and in New South Wales at Nyngan

At first I thought it was a new species, for the tooth (accepted even in the diagnosis of the genus) on the margins of the ventral shells was lacking. Furthermore, the present specimens differ in the following points from the descriptions and figures available to me:

1. The lip is here bulging forth (like a semicircle) in the proximal part.
2. The rostrum and the portion of the head adjacent to the rostrum exhibit a delicate, narrow structure of lines.
3. The lateral seta of the antennule is inserted far more distally than drawn for instance by Stingelin in south-asiatic animals (cf. Zoologische Ergebnisse einer Reise in Ostasien. *Zool. Jahrb. Abt. Syst.* 1904).

Whether these differences are present throughout and suffice for a specific separation, seems doubtful to me, for the feature that, at first. made me think I had a new form before me, proved unreliable, namely the tooth on the margin of the shell. On scanning numerous specimens I happened to come across one in which this tooth was quite normally developed. In any case it is remarkable, that in all other instances the margin of the shell exhibited at the critical spot not a trace of the formation of a tooth. Here a colony is present, in which the tooth, considered up to the present as a characteristic feature of the genus, is quite normally absent, and is exhibited only in very rare specimens, but then quite normally developed. No intermediate forms with for instance stunted tooth formation were seen. Figures 8, a-d.



8. *Dunhevedia crassa* King. a. Lateral View. b. Terminal part of rostrum with antennula. c. Lip. d. Abreptor.

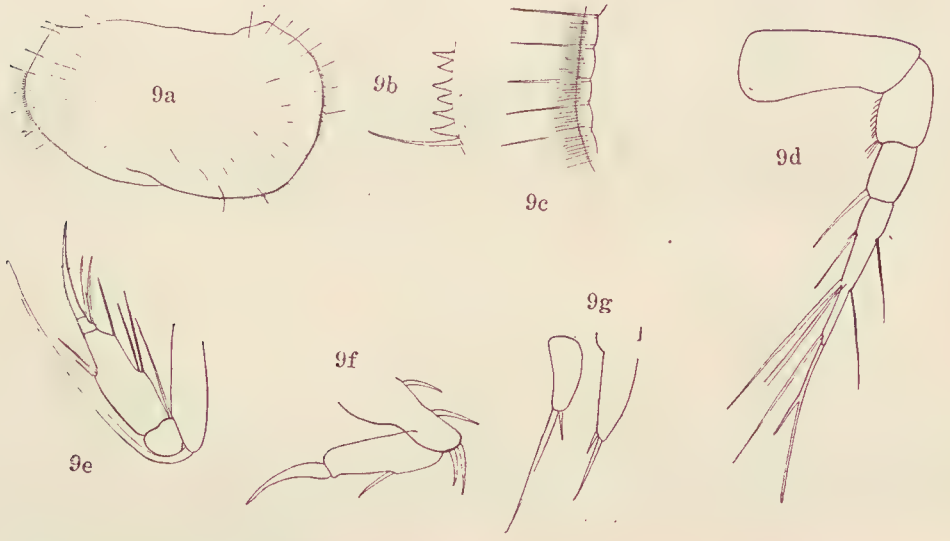
OSTRACODA

While Smith included in his investigations besides Copepoda and Cladocera also Amphipoda and Isopoda, he did not tackle the Ostracoda at all, so that the species mentioned below constitute new ones for the Tasmanian fauna, provided no papers on Tasmanian Ostracoda remain unknown to me. The yield of Ostracoda in Nicholls's collection is low, and it is therefore somewhat premature to attempt to give as yet a general characteristic of the Tasmanian Ostracod fauna. However, even the little material seems to reveal that it consists predominantly of Cypridae and possibly Cytheridae, that Ilyocypridae are infrequent, as well as Notodromatidae (I saw no *Newnhamia!*), Darwinulidae, Candoninae, and Cyclocypridae, for I could detect no representative of these families.

Cytheridae

Limnocythere conifera n. sp.

A *Limnocythere* was found rather frequently in sample 21 from the Cleveland Lagoon. Its shell was unfortunately (as a result of the preservation?) so limp and deformed that I am unable to give more than approximate data on the size and shape of the shell of this species. The length varied about 500 μ. The upper rim of the shell runs about in a straight line, but exhibits on both anterior and posterior ends a bent contour, which was with some specimens much more marked that is shown in figure 9a. The shell did not exhibit any formation of a tooth, which is characteristic for so many *Limnocythere* species. On the surface the shell bore extensive fields, densely set with conical, hyaline outgrowths. These



9. *Limnocythere conifera* n. sp.: a. Lateral view. b. Cross section through shells with conical protuberances. c. Rim of shell. d. Antennule. e. Antenna. f. First leg. g. Furca.

formations were best visible in fragments of the shell, cf. figure 9b. The rim of the shell is conspicuous with long setae, which, for that matter, are dispersed over the whole surface of the shell, and a fringe of densely set short hairs, figure 9c. The antennule carries at its end the forked sensory seta characteristic for the genus, figure 9d.

Figures 9e and 9f reveal the habit and armature of the second antenna as well as the habit of the thoracic extremities, which offer nothing particular. The furca possesses a slightly curved cylindrical stem, quite twice as long as it is wide. It is tapering towards its end and bears terminally one long and one very short seta. As our figure 9 reveals, the longer terminal seta seems to be considerably longer in the female than in the male. This difference might, however, be but accidental, caused by individual variation, since I happened to come across only one male.

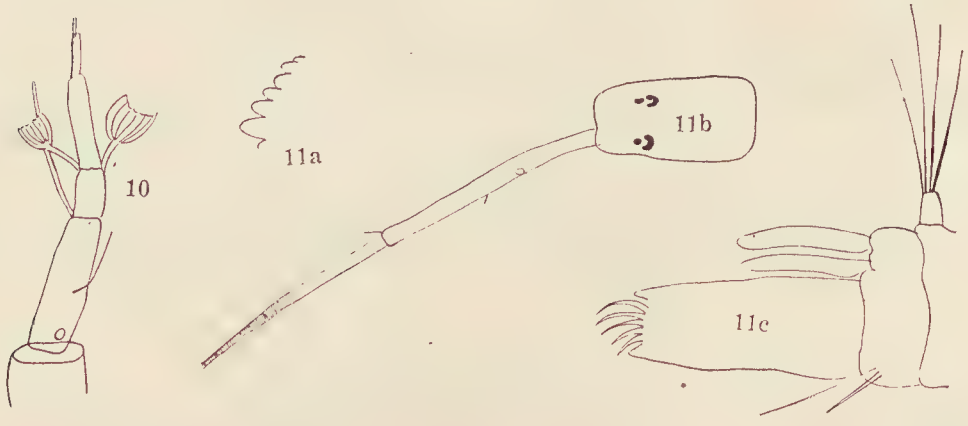
According to earlier communications on Australian Cytheridae it seems that, besides *Gomphocythere problematica* described from New Zealand, there are but two *Limnocythere* known: *aspera* Henry from the continent and the subfossil *L. percivali* from New Zealand.

INSECTA.—DIPTERA

Chironomidae

Many samples contained larvae of Chironomids. These could not be considered, for as is generally known, the determination of Chironomids requires the knowledge of larva, pupa and imago. Only two cases can be discussed here, for they might possibly be new forms.

1. *A larva of a Tanytarsid of the type "Attersee-tanytarsids"*. Sample 21 (from Cleveland Lagoon) contained a greenish larva, 3500 μ long. According to the tables for determination given by *Thienemann* (Chironomiden—Metamorphosen. *Arch. f. Hydrobiol.* Vol. 20, 1929) this had to be classified with Atterseetanytarsus. However, it differs from the latter in the following points: 1. The basal segment of the antenna is but



10. Antenna of a Tanytarsid-larva from the group of "Attersee-tanytarsids".
11. a. Labium. b. Head with antenna; and c. Terminal part of body of a presumably new Corynoneurid.

little shorter than the remaining segments. 2. The remaining segments, too, display different conditions concerning length, as our figure 10 reveals. The latter also reveals that Lauterborn's organs, which are set on stems of about the length of the organs, are not lemon-shaped, but rather calyx or bell-shaped. It would be necessary to reinvestigate with fresh material from the same location, whether this shape of Lauterborn's organ is not an effect of the species.

A presumably new Corynoneurid. Fig. 11. Sample 21 also contained a Corynoneurid larva 3200 μ long, the antenna of which was more than double the length of the head. The ring organ was situated in the proximal third of the antenna and somewhat distally from it there was a small bristle. The basal segment of the antenna as well as the following segment were yellow, the third brown-yellow, which is different from other larvae of *Corynoneura*. Each preanal-papilla bears four bristles. There are four anal gills. The spine at the base of the posterior proleg has a common base with accessory spine, the length of which is about one-third that of the larger spine. The labium possesses a small central tooth, flanked on each side by four even smaller teeth. It could not be determined whether a tiny fifth tooth was present.

New data on Tasmanian water-mites (*Hydrachnellae*) with a list of recorded species

By

Dr. L. Szalay

Budapest, Hungary

(WITH 4 TEXT FIGURES)

Prof. Dr. V. Brehm has handed over for study, some water-mites he had received through Dr. A. G. Nicholls. For this I wish to express my thanks to Prof. Brehm.

We are grateful to Dr. A. G. Nicholls who collected the material in Tasmania. These water-mites, 46 specimens altogether, are from 5 localities. Among them 7 species and 5 genera were determined. These, together, with the localities, are given in the following list:—

1. Big Lake Waterhouse, 12 IX. 1949.
   Limnochares (Cyclothrix) australica Ldbl., 5 ♂♂.
   Eylais Nichollsi n. sp., 1♀.
   Eylais Nichollsi var. *fraterna* n. var., 1 ♀.
2. Cleveland Lagoon, 14 IX. 1949.
   Hydrodroma monticola (Piers.), 6 ♂♂, 6 ♀♀.
   Heterolimnesia Lundbladi. n. sp., 1 ♂.
   Unionicola (Pentatax) longiseta Walt., 1 ♂.
3. Pond 1, Tunbridge, 14. IX. 1949.
   Limnochares (Cyclothrix) australica Ldbl., 2 ♂♂, 1 ♀.
   Eylais (Eylais) extendens var. *tasmanica* n. var., 1 ♀.
4. Lake Leake near Weir, 30. XI. 1949.
   Unionicola (Pentatax) longiseta Walt., 5 ♂♂, 12 ♀♀.
5. Little Waterhouse Lake, 1949.
   Unionicola (Pentatax) longiseta Walt., 1 ♂, 1 ♀.

These, together with descriptions of new species and varieties, are set out in systematic order.

1. Limnochares (Cyclothrix) australica Ldbl.

The specimens examined are closely allied to those described by Lundblad. (1947, p. 13-17, table III, fig. 8-10). Localities: 1 and 3.

2. Eylais (Eylais) extendens var. tasmanica n. var.

Female: This form seems to be near to the species *Eylais (Eylais) extendens* (O. F. Mull.) in the form of the maxillary organ, but differs from the principal species mainly in respect of the pharynx.

The oval body is 3 mm. long and 2·5 mm. wide. Its colour was probably red (all specimens preserved in alcohol).

The width of the eye-plates is 320 μ, length of one eye-capsule is 213 μ, width 131 μ. The anterior margin of intercapsular bridge scarcely rises above the hair-pores, medially considerably sinuated. The capsules slightly sinuated laterally to the middle. The pores of the eye-capsules are very fine. (fig. 1a).

The length of maxillary-organ from the anterior end of mandible to the posterior end overhanging the pharynx, 606 μ, and from the anterior end of the mouth to the posterior processes 412 μ. The width across the bases of the palpi 327 μ. The mouth is comparatively small, more or less circular, length 131 μ, width 142 μ. The chitinous ring beyond the mouth-plate is 180 μ long and 155 μ wide in external diameter. The posterior processes of the maxillary-organ are comparatively short, they curve slightly inward. The maxillary plate is marked with very fine, hardly observable, reticulations nearly to the middle, and with very fine pores at the end. The length of the pharynx is 426 μ, it is slender backwards, gradually broadening about up to the middle (172 μ), from the middle to the last quarter nearly the same width, rounded upwards at the end. The chitinous ring before the pharynx-end is slightly prominent. The surface of the pharynx is covered with fine small granules. (fig. 1b).

The lengths of the segments of the maxillary palpi measured in microns on the dorsal side are as follows:—I. = —, II. = 164, III. = 170, IV. = 311, V. = 196.

Each segment, see fig. 1c, is armed with spiniform setae among which are some pectinate setae. The last segment ends with 6-7 short spines.

The epimeres are mostly anastomosed, armed with reticulate chitinous ridges, the epimeral-plates more or less branching off transversely and possessing very fine transverse connections. This mesh work of chitinous ridges seems to be more thick than in the true species and so thick in places that the epimeral surface seems to be quite porous.

No particulars can be given about the outer genital-organs because the abdomen skin is damaged. Locality: 3.

3. Eylais Nicholsi n. sp.

This new species resembles the European *Eylais* (*Syneylais*) *infundibulifera* Koen. and *Eylais australica* Ldbl. described from Tasmania. The resemblance is mainly in the eye-plates. The maxillary organs and the more or less chitinous structure of the epimera are different. Unfortunately it could not be decided whether it is a species of the genus *Syneylais* or *Eylais*, because only one female specimen was at my disposal.

Female: The oval body is 3 mm. long, 2·5 mm. wide. The colour was probably red.

The eye-plates are 323 μ wide, broader than in *E. australica* (264 μ). The eye-capsules are 196 μ long and 128 μ wide, like *E. infundibulifera*,

they are broader behind than in the front. An obtuse, moderately developed bridge-process exists. On the right and left of this projection a little depression is noticeable. The eye-bristles arise from the front inner-corner of the eye-plates (fig. 2a).

The comparatively broad maxillary-organ extends from the anterior-end of the mandible up to the posterior end of the pharynx (622 μ), from the anterior end of the mouth-plates to the posterior processes, 393 μ long, and across the bases of the palpi, 377 μ wide. The nearly circular mouth-plate is 131 μ long and 139 μ wide. The chitinous ring placed outside the mouth-plate is 155 μ long and 172 μ wide across its interior margin. The maxillary basal plate is richly reticulate and up to one half densely reticulated, so that the surface is covered with big pores at one end, and with dense fine pores at the other. The length of the pharynx is 409 μ, and the maximal width about the middle 213 μ. The chitinous ring before the pharynx-end is very distinct in front. The surface of the pharynx is also covered with fine pores, though these pores are somewhat larger than the pores of the posterior half of the maxillary plate (fig. 2b).

The maxillary palpi are rather slender. Length of each segment on its extensor surface are as follows (in μ) ; I. = 164, II. = 204, III. = 180, IV. = 339, V. = 200. For the structure of the palpi and bristles of the segments see fig. 2c. There are about 6-7 terminal spines.

The epimeres are generally like those of *E. australica,* supported by anastomosed chitinous ridges, mostly crossing the epimeron-plates. The intervals of the mesh-work seem to be relatively narrower in the new form, as in Lundblad's photograph. (Lundblad 1947, A, table IV, fig. 12) of *E. australica,* so that the epimeral surface partly seems to be porous.

The external genital organs in general are like those of E. *australica.* Locality: 1.

With the species described above, (*E. Nichollsi*) there was found at the same place another female *Eylais*-specimen which resembles very much this form. It is known that these *Eylais*-forms are very variable, in spite of these circumstances this specimen will not be identified as *E. Nichollsi,* but will be described as a variety of this form, as there seem to be differences in some characters (body-size, eye-organ, maxillary-organ).

4. Eylais-Nichollsi var. fraterna n. var.

Female: Length of body 3 mm. width 2 mm. thus smaller than the principal species. Body form oval, colour was probably red.

The eye-organs are 327 μ wide. Eye-capsules 188 μ long and 147 μ wide. Eye-organs resemble those of the European *Eylais* (*Syneylais*) *discreta* Koen. Bridge-process does not exist, instead in the middle of the bridge a small stud-like structure (muscle attachment) is noticeable, otherwise the anterior margin of the intercapsular bridge is nearly quite even. The hair-papillae rest on the edge of the eye-capsules (fig. 3a).

The maxillary organ measures 598 μ from the anterior end of the mandible up to the posterior end of pharynx, 409 μ from the anterior edge of the mouth-plate up to the posterior processes and 360 μ in width across the bases of the palpi. The circular mouth-plate is 147 μ in diameter. The chitinous ring outside the mouth-plate measures 180 μ in length and 196 μ in width across its internal diameter. The maxillary plate is thickly

covered with large pores up to half of its area, and is not so distinctly reticulated as in the principal species. The maxillary plate is covered at its end with fine pores. Pharynx is 409 μ long, largest pharynx-width is 221 μ behind the middle. The chitinous ring is prominent in front of the pharynx-end. The porosity of the pharynx is similar to that of the principal species (fig. 3b).

On the extensor surface the segments of the maxillary palpi have the following lengths (in μ) : I. = 131, II. = 164, III. = 172, IV. = 295, V. = 180. For the bristles of the maxillary palpi see fig. 3c.

The anastomosed ridged sculpture of the epimera is generally similar to that of the principal form, but the mesh-work seems to be looser in this variety.

The external genital organs show the same structure as in the principal form. Locality: 1.

5. Hydrodroma monticola (Piers).

The collection contained specimens, which I classified previously as *Hydrodroma monticola* (Piers.), though these little animals do not resemble exactly the form described by Piersig from West Java. Firstly there are size differences. The body length of the male animal described by Piersig is 0·842 mm. and its width 0·800 mm., the male animal of this collection which is described below is about 1150 μ long and 1065 μ wide; and the female animal is about 1260 μ long and 1180 μ wide. The length of the exterior genital organ in the male is 262 μ, and in the female 262 μ; The genital plates are about of the same width in both sexes. The outer sex-organ does not show striking differences.

In the specimen in question, the subcutaneous posterior inner-process of the anterior epimera-group is visible. These processes are medially connected, and furthermore grown together. The position of the concrescence is marked with a scarcely discernible line or groove. Thus it arises between both anterior epimera-groups as a bridge of which the anterior margin is medially protruding (sometimes also the posterior margin of the intercapsular bridge but this is much weaker).

The mandible of the male is (with claw) 344 μ, that of the female 377 μ long. The claws are 65 μ and 73 μ respectively.

The measurements of the segments of maxillary palpi are dorsally (in μ) :—

	I.	II.	III.	IV.	V.
Male	65	82	49	213	90
Female	65	90	57	232	104

This form was recently recorded by Lundblad from different parts of Australia and he noted that the specimens examined by him resemble *Hydrodromo monticola* (Piers.) to such an extent that he did not describe them. It would be desirable to have a detailed description of Lundblad's specimens because the specimens from Tasmania seem to differ from the typical *H. monticola* (Piers.) in some respects. Locality: 2.

6. Heterolimnesia Lundbladi n. sp.

This new form seems to be closely related to the species *Heterolimnesia tasmanica* Ldbl. but some characteristics, especially the structure of the penis-organ, do not permit it to be identified with this species.

Male: Body without prominent epimera 1016 μ, with accentuated epimera 1147 μ long and 852 μ wide. Body elliptical. The original colour of the little animal was not certain, but it was probably brownish-lilac. 1. With the distal lengthening Skin structureless.

Mandible (with claw) 417 μ long. The claw is 106 μ (fig. 4a).

The maxillary palpi are in P. II and P. III rather thick. P. II is especially strongly swollen. This segment has on its ventral side a strong and thick peg set backwards. On P. IV there are about 6 very little and thin hairs (fig. 4b) set ventrodistally.

The measurements of each segment are as follows (in μ) :—

	I.	II.	III.	IV.	V.
Dorsal length of segment	32	155	115	196	53
Distal height of segment	64	131	82	32	12

The length of the four epimera groups are 655 μ. The epimera edges are noteworthy for their strong chitinous margin. Both first epimeras lie quite apart and free from each other, a connecting chitinous bridge is not apparent.

The three pairs of hind-legs, with the exception of the posterior segment of IV, bear swimming hairs and also short strong spinous bristles. Especially on the end segment there are long spiniform setae. The end segment of leg III is slightly curved and provided with three ventral spines. The claws possess a dorsal and ventral spike. The claws of leg III are only a little longer and thicker than those of the anterior legs.

The outer genital plate is of reversed heart-shape and 311 μ long. It is laterally to the middle and on the posterior edge deeply incised. Of the four acetabular groups, the two anterior ones possess 7 and 6 genital acetabulae respectively and each of the two posterior ones 13 genital acetabular (fig. 4c).

The genital opening is 131 μ long. The penis apparatus ends in two curved hooks in the same way as in *H. tasmanica*, otherwise it is differently built. (fig. 4d, s. also Lindblad 1947, p. 48, fig. 31D). Locality: 2.

7. Unionicola (Pentatax) longiseta Walt.

Length 573 μ in the male from the anterior end of the first epimere to the end of the posterior processes of the fourth epimere, 655 μ in the female.

It is to be noted that the specimens studied here are not typical forms, as there are some differences to be observed. For example, we find dorsally on the 5 segments of the anterior extremities some (2-3) bristles and hairs, ventrally and distally 1-2 delicate hairs and on the end of these segments sulcate ones, viz., a large ventral one and a weaker one on the outer side.

The bristling of the epimeres resembles that of *Unionicola* (*Hexatax*) *annulata* Ldbl. (Lundblad 1947, p. 63, fig. 40), in the rather long and fine hair pointing outwards. This hair is not far from the posterior margin of the fourth epimere and attached on the middle. The long hair and the posterior processes of the fourth epimere are readily seen on the specimen in question. In spite of these contrasts, the specimens are considered to be merely different forms of one and the same species, the differences most probably being due to variability. Localities: 2, 4 and 5.

A list of water-mites of Tasmania, on the basis of the data available to the author is as follows:—

1. *Hydrachna (Rhabdohydrachna) approximata* Hal. South Esk River, Longford. Other distribution: West Australia, Victoria.
2. *Hydrachna (Rhabdohydrachna) tasmanica* Ldbl. South Esk River, Longford.
3. *Limnochares (Cyclothrix) australica* Ldbl. Big Lake, Waterhouse, Pond 1, Tunbridge. Other distribution: West Australia, New South Wales.
4. *Eylais australica* Ldbl. The Lagoon, the outflow of the Great Lake.
5. *Eylais (Eylais) contigua* Ldbl. South Esk River, Longford. Other distribution: Victoria.
6. *Eylais (Eylais) extendens* var. *tasmanica* Szal. Pond 1. Tunbridge.
7. *Eylais Nichollsi* Szal. Big Lake, Waterhouse.
8. *Eylais Nichollsi* var. *fraterna* Szal. Big Lake, Waterhouse.
9. *Diplodontus mandibulatus* Ldbl. South Esk River, Longford. Other distribution: West Australia, Victoria.
10. *Hydrodroma despiciens* (O. F. Müll.). South Esk River, Longford. Other distribution: This little animal is a cosmopolitan form.
11. *Hydrodroma monticola* (Piers.). Cleveland Lagoon. Other distribution: West Java, Victoria, New South Wales, South Australia.
12. *Oxus australicus* var. *meridianus* Ldbl. The Lagoon, the outflow of Great Lake. Other distribution: Victoria.
13. *Flabellifrontipoda pectinata* Ldbl. The Lagoon, the outflow of Great Lake.
14. *Limnesia australica* Ldbl. South Esk River, Longford. Other distribution: South Australia, Victoria, New South Wales.
15. *Heterolimnesia tasmanica* Ldbl. Hobart. Other distribution: South Australia, Victoria, New South Wales.
16. *Heterolimnesia Lundbladi* Szal. Cleveland Lagoon.
17. *Australiobates violaceus* Ldbl. South Esk River, Longford.
18. *Australiobates Linderi* Ldbl. South Esk River, Longford. The Lagoon, the outflow from the Great Lake. Other distribution: New South Wales, South Australia.
19. *Australiobates longipalpis* Ldbl. South Esk River, Longford. Other distribution: New South Wales, Victoria.
20. *Australiobates longipalpis* var. *minor* Ldbl. South Esk River, Longford.
21. *Aspidiobates scutatus* Ldbl. Pool near to St. Clair.
22. *Unionicola (Pentatax) longiseta* Walt. South Esk River, Longford, Cleveland Lagoon, Lake Leake near Weir, Little Waterhouse Lake. Other distribution: New Caledonia, Victoria.
23. *Unionicola (Hexatax) minutissima* Ldbl. South Esk River, Longford.
24. *Unionicola (Hexatax) annulata* Ldbl. South Esk River, Longford.
25. *Koenikea (Koenikea) australica* Ldbl. South Esk River, Longford. Other distribution: Victoria.
26. *Koenikea (Koenikea) verrucosa* Ldbl. South Esk River, Longford.
27. *Arrenurus (Truncaturus) tasmanicus* Ldbl. Pool at the Lake St. Clair. the outflow of Lake St. Clair.

Explanation of Figures

Fig. 1.—*Eylais (Eylais) extendens* var. *tasmanica* n. var. ♀. a = eye plates, b = maxillary organ, c = maxillary palpi, inner view.

Fig. 2.—*Eylais Nichollsi* n. sp. ♀. a = eye plates, b = maxillary organ, c = maxillary palpi, inner view.

Fig. 3.—*Eylais Nichollsi* var. *fraterna* n. var. ♀. a = eye plates, b = maxillary organ, c = maxillary palpi from the inner side.

Fig. 4.—*Heterolimnesia Lundbladi* n. sp. ♂. a = mandible, b = maxillary palpi, c = epimera and genital area, d = penis organ in ventral view.

Fig. 1.

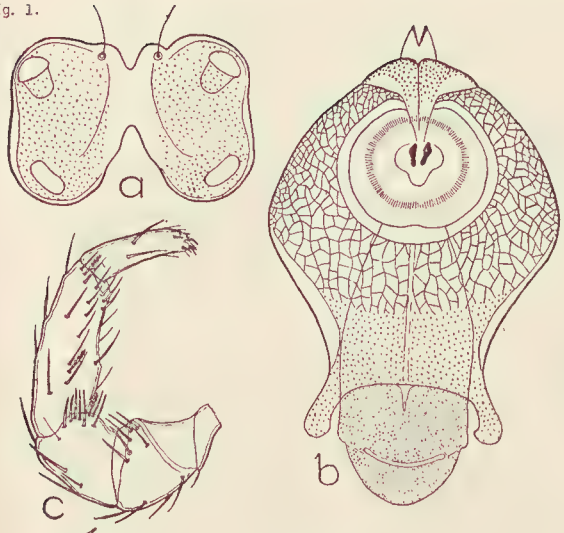


Fig. 2.

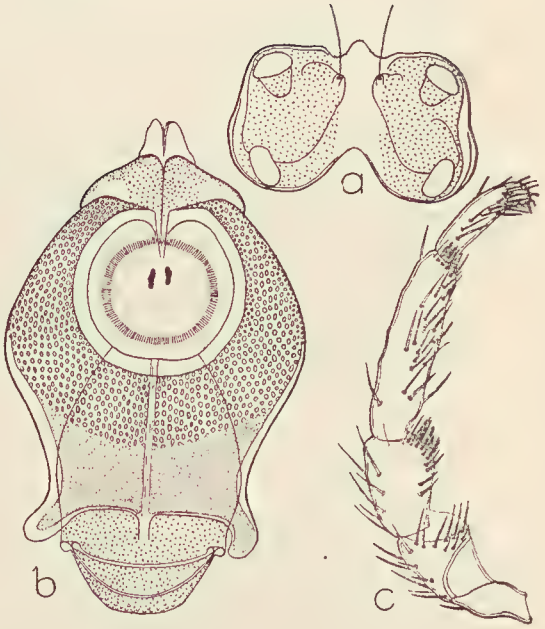
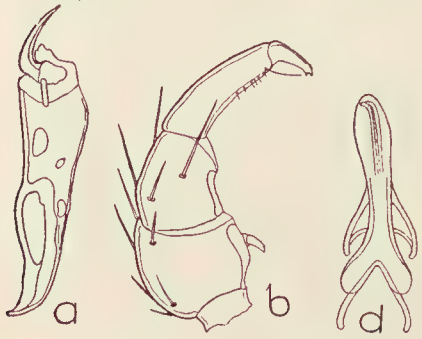


Fig. 4.



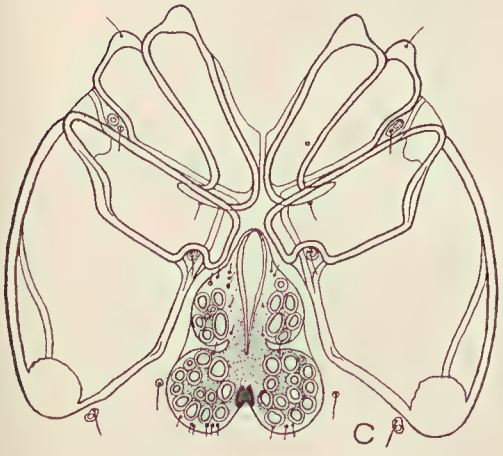
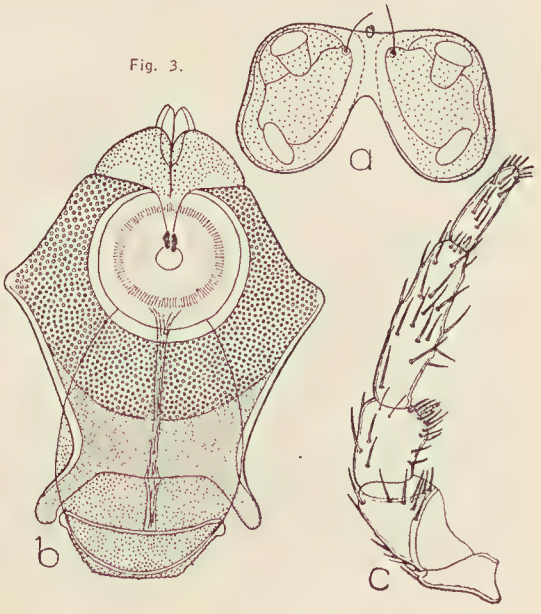


Fig. 3.



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Pap. & Proc. Roy. Soc. Tasmania, Vol. 87 (15th August, 1953)

A New Orchid Species from Tasmania

By

J. H. Willis

National Herbarium of Victoria

(WITH ONE TEXT FIGURE)

Summary

Prasophyllum buftonianum, of the section Micranthum, is described as a new species, apparently endemic in Tasmania. Only the type material is known—collected at Port Davey in 1893.

During the early 1890's the Rev. John Bufton, F.L.S., sent large suites of dried botanical material from Tasman's Peninsula to Baron von Mueller. These were put aside in the Melbourne Herbarium for further examination, and many of the specimens have never been determined. In the beginning of 1893 Bufton visited Port Davey and collected, among other plants, some interesting mosses and orchids which were also submitted to Mueller. W. A. Weymouth dealt with the mosses in these *Papers and Proceedings* (1894, pp. 200-210; 1896, pp. 106-120); but the orchids remained unidentified until July 1949 when the late W. H. Nicholls was persuaded to look them over.

Four plants of a small *Prasophyllum* could not be matched with any available herbarium specimen or description and Mr. Nicholls considered it to be undescribed. I endorse that view, and now publish the plant as a new species under the name *P. buftonianum* (in honour of its discoverer). The following diagnosis is accompanied by an excellent sketch which Nicholls made on 26th July, 1949—from two whole plants and a softened flower.

Prasophyllum buftonianum *J. H. Willis;* species nova (Sect. Micranthi) habitu, statura, ciliorum in perianthio absentia *P. ansatum* R. D. FitzG., *P. densum* R. D. FitzG. et *P. albiglandem* H. M. R. Rupp accedens, sed praecipue differt sepalis lateralia multo latioribus, glandum apicalium absentia, columnae alarum appendicibus duobus valde longis ($\frac{2}{3}$-$\frac{3}{4}$ sepali dorsalis longitudine attingentibus).

A dwarf slender herb up to about 8 cm. high. Leaf lamina narrowly lanceolate, 1-2 cm. long, arising immediately below the inflorescence and sometimes exceeding it. Inflorescence very short (1-1·5 cm.) and congested, greenish brown; flowers about 10, small (2-3·5 mm. long), gibbous and deflexed, not expanding much. Sepals acute with indurated glandless tips, all very broad, the laterals connate at their gibbous base and particularly broad for the section *Micranthum* Rupp. Petals narrow and slightly shorter, acuminate, glandless. Labellum on a stout claw, oblong, more or less auriculate at the cordiform base, slightly contracted toward the acutish apex, with entire or subserrulate whitish margins and a prominent fusiform callus plate (extending to the apex). Column wings very prominent and bilobate with two equal, exceedingly long, acuminate appendages which may attain $\frac{2}{3}$–$\frac{3}{4}$ the length of the dorsal sepal. Anther acuminate at the apex.

Tasmania.—Port Davey (Bathurst Harbour), early 1893, *J. Bufton* 60 *HOLOTYPE* in MEL, *ISOTYPES* in NSW and HO.

The new species is close to *P. ansatum* R. D. FitzG. and *P. densum* R. D. FitzG. (both originally from Mt. Wilson, about 3000 ft., in the Blue Mountains, N.S.W.) and to *P. albiglans* H. M. R. Rupp (1950) from the outer suburban area of Sydney; but from all these it differs in having no apical glands on the perianth segments (at least in the material at present available), wider lateral sepals and much longer sharper appendages to the column wings. The basal auricles of the labellum are less pronounced and the flowers more congested than in *P. ansatum*, its nearest ally. Nothing is known concerning the edaphic conditions under which the plant grows and, as it is a noteworthy addition to the seven pygmy prasophylls already recorded for Tasmania, fresh material from the vicinity of Port Davey (or other parts of the State) is most desirable.

Fig. *a*—Two plants (to scale provided). Fig. *b*—Individual flower, lateral view (much enlarged). Fig. *c*—Flower opened out to show labellum and column details (much enlarged). [Drawing by *W. H. Nicholls*, 1949.]

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Notes on Tasmanian Mosses from Rodway's Herbarium

By

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Introduction

Many years have passed since the publication, in 1914, of volume 1 (Mosses) of Rodway's Tasmanian Bryophyta. In the meantime bryological knowledge has evolved through fresh discoveries and new ideas, and interest has been stimulated by the publication of many works, some of outstanding importance. It results from this advance that Rodway's work now requires revision, and as I am being given the opportunity of studying the material in his collection, it has occurred to me that the publication of notes on the mosses seen and on those appearing in his work, may be of some use to local students of this difficult but fascinating group. I propose to take the families set out in the book, though not necessarily in their order as dealt with there, and to indicate some of the taxonomic and nomenclature changes which, either by more or less common consent of modern workers or by my own predilection, I would recommend to be made. I understand that Weymouth's main herbarium is in England, so it is not practicable to consult it in its entirety, but this disadvantage is lessened by the fact that Rodway's collection contains many specimens supplied by Weymouth. It will be appreciated that the scope of this investigation is greatly narrowed by the limited material available as well as by the paucity of ecological data. No attempt will or can be made to rewrite Rodway's book. General principles of classification, &c., will not be dealt with, and keys to genera and species and descriptions of same as they now stand will not be altered except where necessary. Synonyms will usually be restricted to such of Rodway's names as are altered or dropped in the notes. Frequent reference will be made to Brotherus's work on the mosses in the second edition of Engler and Prantl's Die Naturlichen Pflanzenfamilien, and to Dixon's Studies in the Bryology of New Zealand, Bulletin No. 3 of the New Zealand Institute, and for the sake of brevity these works will be referred to as the " Musci " and the " Studies " respectively.

Family TORTULACEAE = Family POTTIACEAE

Of the genera given by Rodway the following are included elsewhere; *Ephemerum* in Funariaceae, *Holomitrium* in Dicranaceae and *Encalypta* in Encalyptaceae. On the other hand *Tridontium,* which he includes in Dicranaceae, is now treated as of the present family, and the genera *Gymnostonum, Desmatodon* and *Erythrobarbula* are added. *Eucladium* is dropped as a Tasmanian genus.

Acaulon apiculatum (H. f. & W.) Jaeg.

This tiny moss, with its red, immersed, cleistocarpous and globular capsule, is found in New Zealand, and I suspect that one or other, or both, of Carl Muller's *A. integrifolium* and *A. Sullivani* from Victoria, should be referred to it.

Phascum Hedw.

P. cylindricum Tayl. is the only species mentioned by Rodway, but *P. Weymouthii* is added in the Musci as a Tasmanian moss. Both are transferred by Brotherus to *Tetrapterum,* but LeRoy Andrews (The Bryologist, 48: 190) considers that this genus is monotypic and should be confined to the South African *T. capense* (Harv.) Broth. Another *Phascum,* i.e., *P. tasmanicum* Rod. & Dix., was published by Dixon and Rodway (1922). It is described as being near the European *P. Floerkianum* W. & M., with ovate-lanceolate acuminate leaves, margins revolute, and the nerve far excurrent in a squarrose recurved point; cells highly papillose. No particulars of locality, &c., are given and Rodway's collection contains no specimen of this, or any other *Phascum.*

Pottia Furnr.

P. tasmanicum Broth.

I have seen a stem in the collection of what is presumably the original (and sole?) gathering from Brighton, but it is impossible to form a definite opinion on the species from either the material or the description.

P. truncata (Hedw.) Furnr.

This widely spread boreal species is distinguished by the capsule being truncate when empty, and with a long rostrate acute beak. The leaves are oblong or oblong-spathulate with a shortly excurrent nerve and plane or somewhat recurved margins; cells smooth, rather large, irregular in shape; peristome lacking.

I am unable to find any satisfactory differentiating features between this northern species and *P. melbourniana* Dix. or *P. subphyscomitrioides* Broth. Dixon's species, as identified by him, is given for Tasmania (from Glenorchy, coll. Weymouth) by Weymouth and Rodway (1922), and *P. subphyscomitrioides* was published by Brotherus (1916) on Victorian and Tasmanian plants, the latter from Port Esperance, coll. Rodway. It is in his collection sub nom. *P. subphyscomitrium.* In my opinion the Australasian plants are referable to *P. truncata* as a local race characterised perhaps by greater variation in the size of the spores, which can attain 40 μ in diameter.

Pottia Heimii (Hedw.) Furnr.

This is another species with a wide northern distribution. It is reported as new to Tasmania by Weymouth and Rodway in the paper mentioned above. The locality was stated to be unrecorded, and the collector was Weymouth. Rodway's collection also has a specimen from the Domain, Hobart, collected by himself and identified by Dixon. To

judge by this data there may be some doubt as to whether the plant is indigenous. *P. Heimii* is recognisable by the serrulation of the margin of the leaf towards the apex and by the multipapillose cells which at the margin often become smoother and yellowish so as to form a more or less noticeable border. In Rodway's specimen, however, there is no trace of this, but it has the characteristic capsule of the species, the flattened operculum being attached to the columella after maturity. There is no peristome.

Desmatodon Brid.

In this genus the peristome differs from that of *Tortula* in that the teeth are either not twisted or are only slightly so. They are mostly short and often irregular.

Desmatodon convolutus (Brid.) Grout. Syn. *Tortula atrovirens* Londb. *T. recurvata* Hook.

The nerve here is usually thickened in its upper part where its ventral surface is granulose with projecting branched papillae, but this development is sometimes slight or even absent. The basal membrane of the peristome is distinct, but the teeth are short and sub-erect or faintly twisted. *D. convolutus* has a wide distribution in the northern and southern hemispheres.

Desmatodon sp.

There are two packets in the collection which are probably referable to this genus and which look to be an unreported species. Both gatherings are from " Kingston Road " in August 1911. One is sub. nom. *Brachymenium* sp. and contains a few stems of what would be *B. Preissianum* mixed in with the present moss, and the other is labelled *Zygodon obtusifolius* but contains nothing but the *Desmatodon*. There is a superficial resemblance to the *Zygodon* in the obtuse or rounded lingulate leaves, but the structure of the nerve is quite different and the papillae on the cells distinct. Moreover the fruit, such as it is in its imperfect state, is not that of *Zygodon* but would fit *Desmatodon*. The broadly lingulate leaves, with the apex rounded or broadly obtuse and the margin variably revolute, recall those of the New Zealand *Didymodon lingulatus* (H. f. & W.) Broth., which is itself a *Desmatodon*, and the vanishing nerve and the areolation are so much like what is found in the New Zealand species that there is a possibility that the present plant may be a form of that, perhaps the *Gymnostomum Knightii* Schimp. referred to in the Studies, p. 126. As against this, however, Rodway's plants have the upper leaf-cells larger, 10 μ as against 8 μ, and more papillose, and the nerve is rough on the back towards the apex instead of being smooth as in *D. lingulatus*. Nevertheless the differences in the gametophyte are slight and further collections, in better fruiting condition, may show that the plants are conspecific. I could not find any trace of a peristome in the immature capsules seen.

Calyptopogon Mitt.

Calyptopogon mnioides (Schwaegr.) Broth. Syn. *Streptopogon crispatus* (Hampe).

In this striking moss multicellular brood-bodies are present on the ventral surface of the nerve towards the apex. They resemble the gemmae in *Tortula papillosa*. It appears that fruit has not been recorded from Tasmania, but though rare in New Zealand it is not outstandingly so. The perichaetium is sheathing and very long, often exceeding the capsule. The peristome-teeth are strongly twisted to the left, the operculum is erect and as long as the capsule, and the calyptra is mitriform and deeply lobed at the base.

Tortula Hedw.

This and the preceding genera belong to the subfamily Pottioideae where the leaves are usually broad and where the nerve in section shows only one band of stereid cells (i.e., those having thickened walls), this band being on the dorsal face of the wide-lumened (deuter) central cells. The cells in the upper part of the leaf are comparatively large, and the basal cells tend to be lax and hyaline. The remaining genera of Pottiaceae belong to the subfamily Trichostomoideae, where the leaves are mostly narrow and where the nerve has two bands of stereids, one above and one below the deuters. The upper cells are small and obscure and the basal ones narrow. In the present genus the peristome is well-developed with the teeth strongly twisted and the peristome-tube often greatly lengthened. The remaining *Tortula* species in Rodway's work, other than those mentioned below, will be found in *Barbula*.

Tortula princeps De Not.

I have not seen much of the Tasmanian plants of this species, and have not been able to investigate the inflorescence. It is primarily synoicous, but in the New Zealand race it is sometimes dioicous and some of the forms are very troublesome. The lower rectangular leaf-cells are hyaline and thin-walled, those at the margin being in several rows shorter and smaller, sometimes coloured, and forming a more or less distinct border. Rodway's collection has a *Tortula*, from Eaglehawk Neck, East Coast, named *T. brachytheca* " Burchard, n. sp.". The species appears in the Musci as a dioicous *Syntrichia*, the citation being "(C.M.) Broth.". From what I could see, I should consider it as a form of the present species. The distribution is very wide in the northern hemisphere.

T. muralis Hedw.

Almost cosmopolitan. It is an efficient coloniser of lime substrates, such as the mortar of brick wells, &c. In shady and damp stations the hair-point tends to be reduced and inconspicuous.

T. papillosa Wils.

According to some authorities this species has been found fruiting in New Zealand, but this is incorrect; apparently fruit has been known only from Australia. In New Zealand *T. papillosa* is often found growing

on bark in close association with *T. laevipila* (Brid.) Schwaegr., so possibly the latter moss may be discovered also in Tasmania. The two are superficially alike, but the cells in *T. papillosa* are larger and the gemmae quite different.

Gymnostomum Hedw.

G. calcareum Bry. germ. Syn. *Weissia calcarea* C.M.

The plants are small and form very dense tufts on damp rock or earth, usually calcareous. The only gathering so-named in Rodway's collection is from Hobart Waterworks. It is common in New Zealand and has a wide distribution throughout the world. The Studies (p. 117) mentions its author's suspicion that *Eucladium tasmanicum* Broth. was probably, from its description by Rodway, the var. *longifolium* Dixon of *G. calcareum*. I have seen the Frenchman's Cap specimen cited by Rodway and have no doubt that it is referable to the present species. Brotherus evidently withdrew his species as it is not mentioned in the Musci.

Weissia Hedw.

W. Weymouthii C.M. e Rodway

The Studies (p. 114) has a note on this species, Dixon suggesting that, from the description, it is either a *Hymenostomum* or a gymnostomous form of *W. controversa*. From specimens in the collection I take it to be probably the latter. It is quite different from the *W. Weymouthii* R.Br. ter. of New Zealand and, being a later name, would have required changing had it been a good species.

W. microcarpa H. f. & W.

This is a *Dicranoweisia* and is known as *D. microcarpa* (Hedw.) Lindb.

W. bicolor (Hpe.)

I am indebted to Mr. J. H. Willis of Melbourne for information about this species. Rodway cites it from several localities, but the only plant that I have seen so-named in the collection is referable to *Dicranoweisia microcarpa*. It will be noted that he describes them as being very similar. *W. bicolor* appears in Flora Tasmaniae as a *Gymnostomum*, and the name *G. bicolor* Br. & S. is there given (though doubtfully) to a barren plant collected by Oldfield. Mr. Willis, however, has examined European specimens of *Barbula bicolor* (B. & S.) Lindb., which is the same thing, and informs me that Oldfield's plant must be something different.

W. controversa Hedw. Syn. *W. flavipes* H. f. & W.

In this common ground moss the leaves are markedly crisped when dry and the empty capsule is often somewhat furrowed. The peristome is very variable in its development but is always more or less irregular.

Tridontium tasmanicum Hook. f.

Tridontium is a monotypic genus, and the plant has well-marked characters in the very obtuse leaf-apex, robust capsule and trifid peristome teeth. It should be mentioned, however, that at any rate in the New Zealand plant the teeth are not by any means as regularly divided as illustrated in the Musci. The Studies (p. 122) draws attention to the marginal areolation at the base of the leaf and to the thickening of the margin. *T. tasmanicum* occurs also in Australia, and I have received a barren specimen from Macquarie Island.

Tortella (C.M.) Limpr.

In this genus the peristome-teeth are long and spirally twisted, as in *Barbula* and *Tortula*, but the leaf-margins are never recurved but are either plane or incurved. The leaves are much curled when dry, and the basal cells are lengthened and hyaline.

Tortella Knightii (Mitt.) Broth.

Vegetatively there is some resemblance here to *Weissia controversa*, but the basal areolation is quite different, there being in the present plant an obliquely bounded area of long hyaline thin-walled cells which ascends from the nerve to the margin. Moreover, the leaf has undulate margins and is, at any rate in the New Zealand plant, more or less fragile.

T. calcycina (Schwaegr.) Dixon. Syn. *Barbula calcycina* Schwaegr.

The Studies (p. 124) proposes this change of genus, but the Musci retains the species as a *Barbula* in the Section *Streblotrichum* where the critical character is the highly sheathing perichaetium. Dixon, however, considers that the erect margin of the leaf is in favour of *Tortella*, and the elongated hyaline basal cells are no doubt more compatible with that genus than with *Barbula*. The description of the areolation given by Rodway requires to be supplemented by the account in the Studies where mention is made of the two rows of golden cells which adjoin the lower part of the nerve, one on each side, and which are marked with seriate papillae. This character, which is usually exhibited, is a very useful one for identifying barren plants of this moss which in that condition can be troublesome. The fruit is distinct in the long slender seta and high tubular perichaetium.

Erythrobarbula Steere

The plants here were formerly included in the subgenus *Erythrophyllum* of *Didymodon*. The group is marked by the rusty-red colour and the sporadic denticulation of the leaf-apex. The widely distributed northern *E. recurvirostra* (Hedw.) Steere is given by Rodway as a Tasmanian moss as *Barbula rubella* (Hoffm.) Mitt., but the specimens that I have seen from his collection (the localities being Bellerive and Colebrook) are not this species but the allied *Didymodon Binnsii* (R. Br. ter.) Dixon of the Studies. Rodway's description of *Barbula rubella* in some ways is more applicable to that plant than to *D. Binnsii*, but in the absence of authentic specimens I do not think that *E. recurvirostra* should, in the

meantime, be considered as a Tasmanian moss. Both plants are indigenous in New Zealand, and *D. Binnsii* (which I am publishing elsewhere in a new combination) ranked as an endemic.

Barbula Hedw.

This genus has a worldwide distribution, mostly in temperate regions and the number of described species is very large. Steere, in Grout's Moss Flora of North America, remarks that in his revision the seventy-odd species which had been described or reported from that region were reduced to eighteen, this going to show the great inflation of species that had taken place in the genus. The peristome-teeth are, as in *Tortula*, well developed and spirally twisted and the leaves usually have the margins recurved, as there; but the structure of the nerve differs in that two stereid bands are present, the leaves are usually narrower and more acuminate, and the basal cells are less differentiated.

B. australasiae (Hook. & Grev.) Brid.

Rodway's description of this species is somewhat misleading. The leaf margin is not incurved, as stated, but either reflexed or plane, and the peristome-teeth are not, at any rate normally, nearly as long as the capsule, but are quite short. The leaf margin is often bistratose towards the apex. It should also be mentioned that the basal cells are rectangular, hyaline and thin-walled, this being a subgeneric character in *Astericium* C.M. to which the plant belongs. The Musci mentions a *B. nanocaulis* C.M. from Tasmania which presumably is the same thing as a specimen bearing that name in the collection, the author being "O. Burchard n. sp." and the locality Eaglehawk Neck. It is certainly referable to the present species.

B. torquata Tayl.

Rodway omits this species from his book, but it is a recognised Tasmanian moss and is mentioned in the Flora Tasmaniae and other works. There is a specimen in the collection coll. Weymouth, Mt. Dromedary, sub. nom. *Tortula crispifolia*. It is a robust plant, with the leaves spirally twisted when dry with their apices sometimes harshly projecting. The leaves are rather broadly lanceolate with the margins usually closely recurved. The nerve is strong, percurrent or shortly excurrent; the upper cells subquadrate and slightly papillose, the basal cells but little altered and not hyaline. The peristome-teeth are strongly twisted.

B. subtorquata C.M. & Hpe.

This is a derivative of the last species and is close to it, but has the leaves far more narrowly tapering. The basal cells are probably more differentiated, but I have not seen much of the species and cannot feel sure about this. The type collection, from South Australia, has the dry leaves crisped as in some plants of *Tortella*, whereas the habit of the Tasmanian plant resembles more that of *B. torquata*. The latter species is common in New Zealand, but the present one has not been reported from there.

B. pseudopilifera Hpe. & C.M. Syn. *Tortula pseudopilifera* (Hpe. & C.M.) *T. pungens* H. f. & W.

I have found that the nerve structure here is that of *Barbula* and not of *Tortula*, and therefore consider that the original name should be restored. Mr. Willis has gone fully into Australian material referable to the plant and has established that this name is the earliest published of several Australasian conspecific names. Moreover, we have compared the type collection of *Tortula pungens* with the present species and are satisfied that the plants are identical. I think that *Tortula flavinervis* Dix., published in the Studies (p. 144) is certainly the same thing. *T. pungens* is there distinguished by having wider leaves which are not fragile, obscure upper cells and the nerve excurrent in a very short mucro. Since the publication of the Studies *T. flavinervis* has been collected on many occasions and has proved itself to be very variable in the characters mentioned, especially as regards the length of the excurrent nerve. Subject to the qualification that the New Zealand plant has not yet been found in really good fruiting condition I feel satisfied that all the Australasian plants are conspecific.

B. unguiculata Hedw.

Apparently there is only one record of this species from Tasmania. This is given by Rodway as " on ground, New Town ", and the specimen in the collection purports to be from there. To judge from the barren material I have seen the leaves would appear to be too sharply pointed for the species, and moreover the nerve is smooth on the back: but Rodway's description of the fruit seems to agree with that of *B. unguiculata*. I have seen one or two barren plants from New Zealand which may be forms of this northern plant which is the type species of the genus.

Barbula sp.

This moss is in the collection under No. 7, but there is no collecting data whatever. The material purports to be identified by Brotherus as *Tortula pungens* H. f. & W., but there must have been a confusion and mixture because what I have seen of the gathering contained no plants of that species. Some barren stems of *Tortella calycina* were present, mixed with a few fruiting plants of what Mr. E. B. Bartram, who kindly examined it for me, considered to be a *Barbula*. Presumably it is from Tasmania, but even this is not definitely established. I have not seen any Australasian species of *Barbula* to which it could be referred, but in the circumstances I prefer not to propose a new species but to record a short description of what I have seen of it; Stems about 7 mm. high, singly branched at the apex. Leaves crisped when dry, patent when moist, 1·5-1·75 mm. long, linear-lanceolate, acute or obtuse; margins entire, plane above and variably recurved below. Nerve yellow-brown, excurrent in a short mucro. Upper cells very obscure, thin-walled, papillose with low papillae, isodiametrical, ca. 8 μ. Those towards the base longer (to ca. 40 μ), rectangular, thin-walled, smooth. Perichaetial bracts larger, not otherwise differentiated, not sheathing. Seta ca. 7 mm. Capsule 1·6 mm. long, erect, oblong-cylindric, brown, slightly asymmetrical. Peristome

twisted, nearly equal to the capsule; filaments 32, brown, papillose, from a low basal membrane. Spores ca. 12 μ, smooth. Operculum and calyptra not seen.

This has a resemblance to *B. subtorquata,* but differs in the very obscure thin-walled cells and the more bluntly pointed leaves.

Triquetrella C.M.

T. papillata (H. f. & W.) Broth. Syn. *Leptodontium papillatum* (H. f. & W.)

The arrangement of the leaves here is strikingly trifarious and this, with the straggling habit, makes for easy recognition. The dry leaves are closely appressed, and when moistened quickly become spreading or squarrose. It is a frequent pasture moss in New Zealand, and there, as in Tasmania, fruits very seldom. Brotherus, in the Musci, gives the peristome-teeth in this genus as not being striate, but in the present species I have found them to be obliquely and obscurely so. The systematic position of the genus is perhaps somewhat doubtful.

Doubtful Species

Anoectangium (Hedw.) Bry. eur.

This genus is of the subfamily Pleuroweisioideae which Brotherus includes in Pottiaceae, though this is a questionable proceeding. The outstanding characters are the lateral fruit and gymnostomous capsule. The collection contains a specimen of what may well be an *Anoectangium,* but which is barren and so could scarcely be referred there with confidence in view of the fact that the genus has not been reported from Tasmania. The plant is from Colebrook, No. 98, and is sub. nom. *Zygodon intermedius* B. & S., but it cannot belong there. As the nerve is sometimes rough at the back the New Zealand *A. Bellii* Broth. suggests itself as a possibility.

Family ENCALYPTACEAE

The sole genus *Encalypta* appears in Rodway's work as of Pottiaceae, but modern systematists agree in recognising a separate family for it. This is on account of the variation in the peristome which in the genus may be single, double or wanting altogether. The Flora Tasmaniae gives two species, the European *E. vulgaris* Hedw. and the Australasian *E. australis* Mitt. The latter is the only one appearing in Rodway's work, but Dixon in the Studies maintains that it is conspecific with *E. vulgaris,* and this view does not appear to have been contested. Another species, *E. tasmanica* Hpe. & C. M., is listed for Tasmania in the Musci, but Dixon treats this, too, as a synonym.

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Further Observations on the Intertidal Ecology of the Freycinet Peninsula

By

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Summary

This paper is the tenth of a series on the intertidal ecology of Tasmania and it records two important changes in the zonation seen on both the exposed and sheltered coasts. The barnacle belt on the exposed shore has become more densely populated while on the sheltered coast *Mytilus planulatus* has gained ascendancy over *Hormosira*. These changes have led to an alteration in the basic zonation of the shores as well as in the composition of the fauna of the belts concerned.

Introduction

The intertidal ecology of exposed coasts has been described in three previous papers. Two of these (Guiler, 1951a, and 1952a) are concerned with surveys of areas while the third paper (Guiler, 1952b) compares the zonation of exposed coasts with that seen on other types of Tasmanian coastlines.

The field work necessary for these papers was carried out three years ago and all the first described areas have been re-visited during the summer of 1953. Freycinet Peninsula was first visited during February, 1950 and during the re-examination, all of the original transects were studied and changes noted.

(a) The exposed shore at Sleepy Bay.

In the Supralittoral fringe the mollusc *Melaraphe unifasciata* (Gray) was still the only macroscopic organism in the zone. The littorinid appeared to be present in much greater numbers than on the previous visits though the width of the belt is no greater. It is not possible to define the upper limit of the zone due to the discontinuous distribution of the species.

The Midlittoral shows a profound change in that there has been a large increase in the number of barnacles found on the shore. The barnacles in 1950 were few in number but by 1953 they had increased to about three times their previous numbers and they were no longer confined only to cracks but were to be found on the general surface of the rocks. The shore was not covered by a continuous sheet of barnacles but the cirripedes covered patches of rock up to two square feet in area. The evidence seems to point to some sort of barnacle destruction prior to 1950 from which the species are just recovering. *Chamaesipho columna* Spengler is the most common species with *Chthamalus antennatus* and *Elminius simplex* Darwin.

The actual width of the belt, both vertical and horizontal, is no greater than in 1950.

The tube worm *Galeolaria caespitosa* (Lam.) was also present in greater numbers, especially in cracks and between rocks. However, the species is not present in sufficient numbers to form a belt.

By contrast, the Patelloid belt is not as well developed as in 1950. In some places where the belt was previously encountered, it is now absent, though in other places it is still very well developed. The Coralline belt is still present and there has been no change in the Infralittoral Fringe.

(b) The Honeymoon beaches

In the 1951 paper it was noted that the Midlittoral rocks at Honeymoon Beach No. 3 (Transect 12) were populated by *Hormosira banksii* (Turn.), Decaisne and *Mytilus planulatus* (Lam.) and that these species were in intense interspecific competition (see Pl. 3 of 1951 paper). In 1953 this situation had altered and the mussels formed a belt around the shore and have assumed dominance at the expense of the alga.

The small mussel *Brachyodontes rostratus* (Dunker) which formed a band in 1950 around the shore above the *Galeolaria* band had increased in numbers by 1953, forming in some places a dense cover to the rocks. Similarly, *Galeolaria* had also increased from a band of scattered tubes to a uniform covering of tubes on the rocks. There was no evidence of a thick incrustation developing.

The ascidian *Pyura stolonifera* (Heller) = *Pyura praeputialis* (see Kott 1952) has increased in numbers, especially on the stones in the Infralittoral.

Discussion

The most important feature has been the dominance achieved in the Midlittoral by *Mytilus* at the expense, and almost to the exclusion of *Hormosira*. This is in direct contrast to the evidence present by recolonization experiments carried out at Blackman's Bay where *Mytilus* showed a very low rate of successful settlement. Similarly, the spread of mussels, both *Mytilus* and *Brachyodontes*, *Galeolaria* and barnacles supports my contention that a major catastrophe had taken place shortly prior to 1950 and these species are slowly re-establishing themselves.

The relatively rapid spread of *Mytilus* could have been achieved by a successful heavy spatfall or spatfalls, aided by favourable seasons. Since November, 1952, when the Blackman's Bay mussel beds were virtually annihilated the mussels have almost recolonized the whole area which is a further contrast to the results of the recolonization experiments. I cannot advance any satisfactory reason for the rapid and successful recolonization, either at Blackman's Bay or Coles Bay.

The basic zonation at Coles Bay no longer includes *Hormosira* which has been reduced to the status of " another species ". The zonation is now as follows:—

Melaraphe
Chamaesipho and *Austrocochlea*
Brachyodontes
Galeolaria
Mytilus
Corallina
Cystophora

The zonation on the exposed coast is not altered but it has been rendered more obvious by the greater population of the barnacle belt.

The greater density of population on the exposed coast will have led to a larger number of individuals which can shelter around the barnacles but the complete change of dominant species at Coles Bay will have led to more profound changes. *Hormosira* does not support a large fauna or flora but mussels support a large number of species which live below them, such as crabs, annelids, flatworms and other molluscs. Similarly a number of algae live attached to the shells of the mussels and barnacles also settle on lamellibranchs.

These observations stress the necessity of frequently visiting shores which are described as type ecological areas and so noting the ecological changes occurring thereon.

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THE GEOLOGY OF THE DOVER DISTRICT

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WITH 3 MAPS

Abstract

An area of 80 square miles around Dover consists mainly of Jurassic dolerite in the form of sills and dykes. The faulting accompanying the intrusion has cut the area into a series of fault blocks all of which occupy a graben. Some Tertiary faults cut through this graben but they are not very well marked except in the west where they dominate the structure.

The Permian and Triassic rocks are part of an orthoquartzite-limestone suite derived from a low terrain. The Permian rocks show some change of facies and resemble the Marlborough sequence. The Woodbridge Glacial Formation is extremely thin. The Triassic Knocklofty and "Felspathic" formations are of the usual types.

Syenite-porphyry dykes together with gravels, sands, and clays are the only rocks seen that are younger in age than the Jurassic dolerite. All the clays tested were kaolinites with minor impurities.

Introduction

The area mapped is situated on the western shores of the Huon River and D'Entrecasteaux Channel between White Bluff in the north and Tower Bay in the south. The northern portion extends westward to the Huon Highway but, to the west of Port Esperance, the boundary lies along the foothills of Adamson's Peak. The total area mapped is about 80 square miles.

The geology of the area was done by tracing the outcrops on the ground and locating these on aerial photographs. A base map was constructed from the aerial photos by the slotted template method. The details of tracks and roads were obtained for the most part from the Forestry Commission's Adamson maps, sheets 4, 8, and 12.

Altitudes were taken by aneroid barometer but, as no base readings could be taken to check against, these can only be considered as indicating the order of difference in height of the various localities. In other places, heights have been taken from the form lines of Sheet No. 6 of the Lands and Survey Department's 4 miles to the inch map of Tasmania.

Discussion and Conclusions

The districts around Police Point, Dover, and Strathblane were mapped geologically and rocks belonging to the Permian, Triassic, and Jurassic Systems with minor patches of Tertiary and Quaternary age were found to outcrop.

The area occupies a downthrown fault block which is deeply dissected by the Esperance River system and partly submerged. The Jurassic dolerite—the most abundant rock type present—dominates the physiography, capping the highest hills and ridges. The relief is fairly low.

Faulting is seldom pronounced here but close jointing is apparent everywhere. The faulting that accompanied the intrusion of dolerite has cut the country into a patchwork of Permian and Triassic sediments, the latter of which occupy the larger area. Later faulting is revealed in aerial photos as marked lineaments across the dolerite but the faults in the main part of this area show small displacements. In the west of the area, this Tertiary faulting assumes a major role. Here faults of perhaps 500 feet throw have elevated the Triassic sediments to over 4000 feet.

The coarse sandstones interbedded with creamy argillites carrying a predominantly bryozoan fauna of Permian age are considered to resemble the Marlborough Group. This is succeeded by coarse tillitic conglomerate considered to be a thin glacial facies of the Woodbridge Mudstone. Above these a normal to perhaps slightly sandy Ferntree Mudstone is found. One exposure of the Ferntree Mudstone contained a coarse conglomerate bed about four feet thick. The Cygnet Coal Measures appear to have been completely eroded in this area.

The Triassic Basal Grits succeed the Permian beds over a slight disconformity which is indicated by a basal conglomerate in some places, by the undulatory nature of the contact, by the change from mudstones to sandstones, and, more positively, by the inclusion of pebbles of the underlying mudstone in the conglomerate bands. This ' grit ' is rich in red and pink garnet.

The Knocklofty Sandstone and Shales show interdigitating beds of sandstone and shale, saliferous beds, and many sedimentary structures including numerous slump structures. The colour is very variable. This formation may be in the vicinity of 600′ thick.

It is succeeded by beds of the ' Felspathic ' Sandstone which is everywhere overlain by dolerite so that no complete section of this has been seen. This formation carries the coal seams explored on the Strathblane coal field.

The syenite-porphyry at Brook's Bay and the extreme north of the area occurs in dyke form and is probably of Tertiary age. Clays and gravels seen at various places may be of Tertiary or Quaternary age.

At present the rejuvenated streams are eroding towards base-level. The sea-level, although high enough to drown the mouths of the rivers, has not yet reached its former height.

The Permian and Triassic sediments were probably deposited as part of an ortho-quartzite-limestone suite. The mineral content suggests that the terrain was low and composed of metamorphic, acid plutonic, and less abundant basic rocks.

An examination of some clay material shows that it is mainly kaolinite with much quartz and a little illite always present.

Physiography

When viewed from Adamson's Peak, it can be clearly seen that the area under consideration belongs to an extensive physiographic unit distinctly different from the more westerly hills. This unit extends along the coast from Mt. Leillateah in the south to the Kermandie Divide in the north and is bounded in the west by the ranges linking the Hartz mountains, Esperance Peak, Adamson's Peak, Mt. Alexandra, La Perouse, and Mt. Leillateah.

The elevation of this country is fairly low, rarely reaching a greater altitude than 1600 feet. Large portions of it reach an elevation of about 600 feet. The relief is subdued by the deep weathering and is not very noticeable because of the smoothing effect of the heavy vegetation.

Without exception the highest hills are dolerite-capped and, in the case of the highest elevations, namely Mt. Esperance and its north-westerly extensions, the mountain south of Port Esperance, Green Hill, and Burns Hill, the dolerite is continuous down to the sea-level. The tops of these hills are usually reached over very steep, scree-covered slopes but in some places (e.g., Burn's Hill to the west) cliffs of about 200 feet in height have been formed. "Ploughed fields" are uncommon because of the low elevation and the rapidity of the weathering in this area. Westward of Green Hill, Triassic sediments stand at 1200 feet.

In general this fits the Midland Type of terrain described by Lewis (1944) in that it has hilly relief and is a mosaic of faulted blocks of Permian and Triassic sediments intruded by dolerite and, after peneplanation and uplift, these blocks have been dissected to form a number of comparatively low ridges. The order of elevation, namely about 2000 feet, also fits Lewis's criteria. However it differs somewhat in that no hills composed entirely of sediment reach the same altitude as the highest dolerite hills.

This whole unit appears to be part of a fault trough bordering D'Entrecasteaux Channel. There is no evidence that this area has been uplifted as a whole since the injection of the dolerite. However it is possible that the seaward (i.e., higher) portion of the area may be due to a more recent uplift. The westerly portion has been formed by differential erosion. Within this larger province, several distinct physiographic provinces can be recognised.

Huon River—Glendevie Area

Lying between the Huon River and a backbone of dolerite which is practically parallel to the shore in this area, is a plateau at a height of between 500 feet and 600 feet occupying a dip slope on the Knocklofty beds. It extends from behind Surges Bay to Desolation Bay. In this area the shoreline consists of a narrow shore-platform showing in many places a wave-cut notch in a cliff of about 50 feet. This cliff extends, except for a few narrow breaks where small streams join the river, from Surge's Bay to Police Point. The distance from the marine cliff to a prominent cliff-forming bed in the Knocklofty Sandstones varies from about 1½ miles at White Bluff to about 440 yards at Desolation Bay. These inland cliffs vary from 10 to perhaps 100 feet in height.

The surface of the plateau dips gently to the south-west and is composed of well-drained ridges of resistant sandstone covered with thick vegetation separating button-grass plains in shale. Towards the dolerite the ground rises in very steep slopes with evidence of landslides occurring where the easily-eroded felspathic sandstones and shales have failed under the load of dolerite.

The creeks in this area have cut deep steep-sided gullies in the escarpment down which they flow in a series of cascades. The creek that falls over the cliffs above the Glendevie-Brook's Bay Rd, unlike most

of the drainage which originates in the dolerite, rises near the escarpment and flows westwards across the button grass plain until it is turned by a sandstone bed along which it flows in a northerly direction to the main north-easterly-trending valley. The head-waters of this creek may eventually be captured by the more vigorous streams flowing to Desolation Bay.

All these creeks are youthful mountain torrents deeply embedded in the soft weathered surfaces of the Triassic sediments so that they often appear as trenches about 2-3 feet wide and 5-6 feet deep.

The next unit is the dolerite ridge stretching in a north-westerly direction from Huon Pt. to Glendevie. This ridge is sharply rounded in a cross section and has few distinct breaks along its length. The altitude of the ridge does not vary much but it is highest in the direction of Glendevie.

A strong lineament in the same direction separates this main ridge from a south-westerly extension of the dolerite which widens considerably towards Pt. Esperance. Another lineament in a somewhat similar direction cuts off the extension that forms the steep hills north-east of the township of Dover. All this area is characterised by steep but not precipitous slopes in the dolerite.

The drainage is not well developed in this area. It tends to be dendritic in the patches of sediments but follows rectangular joint patterns in the dolerite. Swampy areas covered with thick vegetation are connected by straight creeks flowing in relatively shallow beds on the bare dolerite.

The beach along this part of the Huon River except at Surveyor's Bay extends to the marine cliff. In the sediment west from Surveyor's Bay, the shore follows strong joints and a rather wider shore-platform than usual has been formed.

Where the wave action has cut along the strike of sediments, sandy beaches such as that at Surveyor's Bay have been developed. Where dolerite occurs along the shoreline and where there is sufficient protection, shingle beaches are formed but elsewhere the dolerite shores are steep-to and surmounted by cliffs up to 100 feet high. Where prominent joints at right angles to the beach occur, gulches with vertical or nearly vertical sides have been cut out by wave action. All the prominent points in this portion of the river are in dolerite.

Red Cliff Area

The shoreline from Roaring Beach to Esperance Point reflects the increased exposure of the sediments to wave action. The height of the land behind Esperance Point is due to the resistant dolerite which is protecting the sandstones behind it. The only sandy beaches exist at two places where dolerite sills at and below sea level are affording protection.

The sediments have been rapidly undercut and eroded so that a very narrow wave-cut platform exists along this coast. In most places this platform is covered with fallen blocks of sandstone from the marine cliffs which reach a maximum height of 300 feet. Very extensive landslides have been produced by undercutting and this method of coast formation has eliminated the possibility of offshore reefs and stacks which

occur at one point only, namely at Adamson Run 4 No. 25170 at a distance of 1·6″ bearing 79 degrees from the centre point. Prominent joints have been carved out more deeply than the rest of the sandstone but do not provide the same contrast as exhibited in the dolerite.

The detritus from this erosion has been collected on Roaring Beach where extensive source-bordering sand dunes have been formed. These dunes have formed a dune-barred lagoon where a small creek reaches the sea near the westward end of the beach. They have deflected the stream to the west so that it now flows along the foot of a steep dolerite scarp. The dunes reach a height of about 10 feet and are now well anchored by vegetation. These dunes border a flat area which stands about 10 feet above present sea-level and extends back to the dolerite hills. This low area appears to be in dolerite and may represent an old shore platform.

A feature often seen along this part of the shoreline is an old bench at about 40 feet above present sea-level which, in many places, carries sea-shells of similar species to those living in the same areas today. This bench is most noticeable just below the farm-house at Blubber Head (Adamson Run 5 No. 25278, distance 2·7″ bearing 87 degrees.) While it is possible that the shells could represent old kitchen middens, it seems more likely that this represents an old shore-line.

Port Esperance Area

Port Esperance shows the following characteristics of a submergent type of coastline. It is highly indented, contains numerous islands surrounded by reefs, many partially or completely submerged rocks, an uneven bottom while small deltas and mudbanks are forming at the mouths of some of the creeks. The harbour has been enlarged in a north-westerly direction, i.e., in the path of the most vigorous wave action and also away from the dolerite of the southern shorelines. The shape of the harbour has been controlled by the dolerite outcrops particularly by the dolerite of Pt. Esperance.

Hope Island, Rabbit Island, and the little islands inside the mouth of the Esperance River consist of dolerite. They show typical shingle beaches, rounded sparsely vegetated surfaces, and rapidly deepening shores. Faith Island, Charity Island, and the larger part of the small island at Adamson Run 5 No. 25273 distance 2·5″ bearing 179 degrees are composed of Permian rocks, the two former in the Ferntree beds, and the latter in the Woodbridge Tillite. They have rocky shelves, ledges, projecting reefs, and small marine cliffs. Faith Island is the most exposed of these. It shows the typical dense vegetation with a few eucalypts carried on a very thin clayey soil. The vegetation gives the impression that the island is higher than is actually the case. The rock and soil cover stands only 2-3 feet above high water mark and is very small in area. The combination of a high tide and rough sea will eventually convert this to another partially submerged shelf such as can be seen off-shore at the east of the harbour. In the last decade the island has lost about half its area under these conditions.

Very active deposition is taking place inside the mouth of the Esperance River where extensive mud flats and islands have been deposited in sheltered localities. The islands between Raminea and the mouth of Chale Bay have all been built by deposition from the rivers.

Small sand dunes (10 feet high) have been built behind the sandy beaches along the northern shore. These have barred the creeks entering here and small lagoons have been formed. The general shape and character of this area is that of a partially submerged coastal plain.

In many places around the harbour there appears to be two benches. The first one at about 10-20 feet above present sea-level appears to be cut in another level which is represented by the general level of the rounded hills and ridges standing at from 80 to 100 feet above the present water level of the harbour and streams. To the east of the sports ground at Raminea, the surface at the higher level carries gravel.

On looking in a south-easterly direction up the Creekton Rivulet valley, an impression of the former maturity of this valley is gained. However, the rounded surfaces are those rising not from the present stream bed but from a level at about 40 feet above this. The slopes between this 40 foot level and the 100 foot level are fairly smooth and overlapping spurs have been eliminated to a large degree. Above the 100 foot level the slopes rise steeply to the dolerite hill tops.

The present streams show youthful features and are cut into the 40 foot level. Rapids, miniature overlapping spurs, and sheer walls up to 100 feet high demonstrate their youth. As yet no definite undercut banks and slip-off slopes have been developed but, above the present river level near Raminea, some well-developed examples of this phenomenon are to be seen.

Another indication of the youth of this rejuvenated tract is the close relationship between the local joint pattern and the course of the river from the dolerite to Pt. Esperance. There is in this area a complicated system of vertical joints, the main directions of which are approximately 84 degrees and 170 degrees with minor ones at 59 degrees, 125 degrees, and 144 degrees. The strike of the sediments bears 219 degrees. An examination of the map will show how closely the Esperance River follows the rectangular major joint pattern in this locality.

Meads Creek Area

The most rugged topography of the whole area is to be found in the dolerite hills south of Pt. Esperance. These hills which are arranged in long ridges running approximately north to south reach a maximum height of 1635 feet and are higher than any other land in the area being dealt with.

The hills rise sharply from the coastline and are drained by intermittent consequent streams which follow the rectilinear jointing of the area. Two deep valleys, separated by a relatively low saddle, occupy a lineament running southward from Meads Creek and divides the area into two distinct parts, the higher of which is to the south-west of the lineation. Another lineament running north-west from Tower Bay is occupied by the largest stream of the area. This stream flows south-east. Beyond the high ground but in the same lineament, a deep valley has been cut down which flows a tributary of the Creekton Rivulet.

The creeks of this area have steep youthful valleys and are choked with dolerite boulders. The ground surface is strewn with boulders but bare rock often appears. Dense vegetation covers the valleys and the scattered swampy flats but the hillsides usually carry scattered eucalypts and sedges on a thin, stony soil.

The coast from Pt. Scott to Tower Bay is in dolerite and except towards the southern portion where rectangular inlets have been formed it is relatively straight. The straightness of this coast and its jointed nature apparent at Pt. Scott suggest that this is a faulted coastline. The marine cliff stands at between 100-200 feet above the shore which is steep-to. No reefs or islands appear. There is a narrow shingle beach at Adamson Run 6 No. 25281 distance 1·4″ bearing 257½ degrees but the rest of the coastline is in massive dolerite. It is possible that, exposed as it is to the full force of the wave action, this is a mature submerged coast, a type of coast almost indistinguishable from a faulted coastline.

Raminea Area

The next province to be considered is that lying along the western portion of the area immediately below the foothills of Adamson's Peak. Here two button-grass plains in Triassic sandstone separated by a rounded dolerite ridge standing at an altitude of 1000 feet, show very similar features. The northern plain is called the Raminea Plain while that to the south is known as the Strathblane Plain and both occupy about 2000 acres of low-lying ground.

The Raminea Plain consists of a number of extensive flats of swampy nature presumably developed in shaley beds separating long ridges of quartz sandstone. The sluggish drainage finds its way through these ridges in an easterly direction to the Esperance River which flows along the eastern side of the Plain. The western edge of each plain is bordered by steep dolerite-capped hills separated by creeks showing steep V-shaped valleys in the dolerite but flowing in broad, mature valleys in the softer rocks below.

From the Esperance River's present bed, three main levels occur. In the south the first which is not very extensive stands at 12 feet and it is in this level that the river is at present degrading. The areas at this level stand on what would be slip-off slopes formed at an earlier stage of the present cycle of rejuvenation. However at many places a steep bank has been cut in this level and slip-off slopes are forming at the base of this bank. The cliffs on the undercut slope have been increased in height because the river appears to be following the same course as at the higher level. At the northern boundary of the area, there is a large area covered with alluvium across which tributaries draining swamp land meander before falling down rapids in sandstone to join the main stream.

Another more extensive area stands at about 35-40 feet above the present river level. In the southern part of the plain this level extends back along the tributary streams rising to about 150 feet above the stream at the extreme west of the area. Most of the plain is at this level and, in it, the creeks meander sinuously through the sand weathered from the underlying sandstone which is usually disintegrated to a depth of from 4 to 8 feet.

This 40 feet level has been formed by the dissection of a higher level standing at about 80-90 feet above the river. Looking over the plain this appears to be quite extensive but actually it is composed of isolated hills separated by the main drainage and really occupies only a small area. The tops of these hills are in sandstone or, commonly, in a granule conglomerate. Towards the dolerite, the land rises in steps formed by rises

in shale surmounted by treads in the sandstone beds. Above this, the concave slopes in dolerite rise steeply.

The Esperance River in this area tends to follow the major jointing but, in some places, it has cut along the strike of a soft bed in the Triassic. The river either forms rapids over the beds of hard sandstone or turns against them to cut its bed along the strike of the soft shaley beds. This type of control is also seen in the lower parts of Wobbly and Big Creeks.

From just below the junctions of these creeks and the river, the course is parallel to a cliff in sandstone that rises abruptly either from the river or from the old slip-off slope that occurs to the east of the river bed. This cliff, probably a fault scarp, stands between 120 and 150 feet above the river which is increasing its height at the point just above the main bridge of the tram-line by actively undercutting it.

The contact of the sandstone and dolerite has been cut so that the outcrop is V-shaped down-stream following the dip of the sediments and indicating that the dolerite here is a sill over the sandstone.

Any evidence that this plain was formed as a slip-off slope for the Esperance River which, in this case, would have migrated eastwards to its present position, is missing. The only level on which this could have taken place is the upper one and this is not continuous enough to draw any such conclusion. The valley of the river appears to be mature in cross-section above this point but, as elsewhere in this district, rejuvenation has resulted in a valley-in-valley structure.

Strathblane Area

The Strathblane Plain, although similar in many respects to the above, shows many differences. This is due to the fact that the Creekton Rivulet has not the eroding power of the Esperance River. In some areas (Run 8, 2974 and 2·1″ bearing 126°) it has formed small levees showing that the steam—barred by the dolerite towards Raminea—has reached a local base-level.

The main stream and its tributaries meander sluggishly across the broad swampy plain which is not as well drained as the Raminea Plain. The ridges that traverse the plain are not so high here, standing at the most, only about 10-20 feet above the streams. They are completely weathered to sand in most places but, in a few of the deeper cuttings near the Hastings Road, sandstone has been revealed.

At the north-eastern end of the plain, river gravels have been deposited. Odd pieces of rounded rock fragments have been found quite high on the hills on either side of this creek to the south-west but very little has been seen across the plain itself suggesting that it has been eroded away. The heavy alluvium such as at the north end of the Raminea Plain is missing.

A feature common at both plains is the evidence of heavy flooding. Old tram sleepers, bridges, and bearers have been swept through dense scrub while sand drifts of considerable size are common above ordinary stream levels.

The low divide between this drainage and that flowing toward the south is being rapidly cut northwards. The capture of the Creekton Rivulet is certain and could easily be done artificially now.

From the above it can be seen that the main drainage system and the only considerable one of the area is the Esperance River and its tributaries. The Esperance itself rises in the Hartz Mountains and flows along a remarkably straight south-easterly-tending valley until it is joined in the Raminea Plain by its two main tributaries, Wobbly and Big Creeks. Here it turns southward and finally eastwards through a dolerite-walled gorge into its estuary at Raminea. The Creekton Rivulet joins it from the south-west at Chale Bay which is the drowned mouth of this rivulet.

General Notes on the Physiography

The history of the development of this topography presents many problems such as the age of the various features, the relative merits of uplift against eustatic fall of sea-level in causing the latest rejuvenation, and the fact that the entrance to the Huon River, Pt. Esperance, and Southport are all cut in dolerite.

As there have been no fossils found in the area that are younger than the plants of the Trias-Jura coal measures, the time scale must be based on the Jurassic dolerite that overlies these beds. Therefore the development of the present topography could have dated from the cessation of the dolerite intrusion.

However in view of the evidence from other parts of Tasmania, it is considered that this area forms part of the uplift that occurred during the Tertiary faulting. The higher coastal area is succeeded westward by the lower block containing the two plains. The next dolerite west from there stands at 4000 feet on Adamson's Peak indicating that these uplifts were post-dolerite. If we accept this time scale, the formation of the features must have commenced early in the Tertiary.

The 100 ft. level of the Raminea Plain and elsewhere probably reflects the differential erosion (over the period from the uplift until now) of sediments as compared with the dolerite which everywhere rises from this level. Or it may be due to continued erosion at a higher sea-level than now. A point against the first conception is the occurrence of the river gravels and transported material at about this level in many localities. These river gravels contain boulders of the material now at the surface on the 100 ft. level upstream. Therefore it would seem that river level was at this height for some time whilst the erosion was taking place.

The 40 ft. level indicates that sea-level remained steady at this height above sea-level for sufficient time to allow the streams to achieve a fair degree of maturity. The heavy deposition of alluvium, probably tillitic, in the Esperance valley suggests that this level antedates the last onset of glaciation in Tasmania. The level standing at about 10-15′ indicates another former sea-level.

This glaciation would cause the rejuvenation of the area by the consequent lowerings of sea-level. The old river course as indicated by soundings was excavated to a depth of 120′ below present sea-level and ran along the dolerite shore south of Hope Island.

A point of interest is that although the area is a submerged one, the streams are still degrading. This shows that the sea-level, now rising, has not yet reached the level at which the mature valleys were formed.

It is likely that these changes of sea-level are intimately connected with the Pleistocene glaciation of Tasmania and have therefore occurred after any faulting accompanied by up-lift.

Another point worthy of notice is that the mouths of the Huon River, Esperance River, Pt. Esperance, and Southport have been cut through quite massive dolerite, although in each case an easier alternative route through sediment could have been taken. This suggests that the drowned streams originated in the rocks covering the dolerite. In the process of cutting out their valleys, the streams tended towards the lower sides of fault blocks and in this position were superposed on the underlying dolerite. It is possible that the dolerite was thin in these localities or that the streams attacked along big joint planes or faults.

In general this rejuvenated landscape shows certainly two, and perhaps three cycles in its development.

Chemical weathering processes have been extremely active in this area so that a deep weathered zone, often as much as 20′ and usually about 10′, covers most of the beds. This leads to a general lack of outcrops over the area. This is particularly true of the areas under thick vegetation where often even fragments of rocks cannot be found.

Creek beds, usually useful for providing outcrops, are covered with mixed alluvium from outside the area or choked with sand and mud to such an extent that no outcrops can be seen.

Felspathic sandstone which has been proved to exist by mining operation, does not appear on the surface at any locality. No shales appear except as landslide detritus along the coast and, over large areas, the sandstones have disintegrated to sand to a considerable depth.

The limited Permian rocks are more resistant and outcrops of them can usually be found unless covered with stream deposits. The dolerite also outcrops either as abundant boulders or often in scarps.

However, good but narrow exposures of the rocks are to be found right along the coast, along the shores of Port Esperance, and along the Esperance River. The roads and the very numerous old tramlines with their many deep cuttings also provide a great many exposures.

Stratigraphy

The beds found in this area are restricted to part of the Permian beds, the Trias-Jura beds, the Jurassic dolerite, together with scattered remnants of Tertiary deposits and Recent deposits. Of these, the dolerite is by far the most abundant and occupies more than half of the total area. About 30 per cent of the area is in the Mesozoic beds; Permian rocks occupy less than 20 per cent of the whole area.

A feature common to all beds is the intense jointing present. It would be difficult in the dolerite, in most of the Permian sediments, and in the shales of the Triassic beds to mine a piece of rock a yard square without it breaking along a joint. The Woodbridge Tillite and the Mesozoic sandstones tend, perhaps because of their original compressibility, to occur in larger blocks but even here the jointing is most pronounced. The Ferntree beds often assume the rectangular to polygonal type jointing called tesselated paving. The blocks usually have sides less than a foot in length.

The observation of Banks (1952) concerning the marked abundance of sedimentary structures in the Triassic sediments compared with those in the Permian rocks is amply confirmed in this area. Generally, as he states, the Permian rocks are flaggy or massive with some shaley bedding and lamination. However the shaley beds are definitely very much less apparent here than in the Hobart district. As well as current bedding and rolling strata in the truncated Cygnet Coal Measures of this area, slump structures, current bedding, contemporaneous faulting, and local miniature disconformities can be seen in the Risdon Sandstones and Conglomerates.

Because of the jointing and the rather flat dips of the beds, measured sections could not be accurately determined.

PERMIAN SYSTEM

The Permian rocks in this area outcrop along the Huon River, around the northern shore of Pt. Esperance, in the Dover Rivulet valley, and along the lower reaches of the Esperance River. They appear again in the bed of the Esperance River just beyond the northern boundary of the area and have been reported by Mr. J. N. W. Elliston (personal communication) at Lady Bay. To the west they outcrop in a series of fault blocks along the flanks of Adamson's Peak.

The total thickness of Permian sediments visible in this area nowhere exceeds 1,000 ft. and may be actually considerably thinner. The lowest horizon visible is a silicified fossiliferous mudstone which has been intruded by a dolerite sill near the coal bins of Folkestone. This underlies rocks which are tentatively correlated with the Grange Mudstones (Adamson Run 5 Photocentre 25272 Distance 2″ Bearing 165°).

The topmost formation recognised is the top of the Ferntree Mudstones which may, however, in some places carry the truncated remnants of the Cygnet Coal Measures. The top of the Permian is often the locus of a dolerite intrusion—usually a sill transgressing into the Triassic rocks. Where there is no intrusion, a disconformity under the Basal Grits of the Triassic System is found.

By comparing observations made in this area with the Permian of the Hobart district, it would appear that there is a facies change indicating a shallower environment towards the S-W.

The lowest bed of the Permian in this area, as mentioned above, outcrops on the southern bank of Esperance River at Folkestone. It is a silicified mudstone containing abundant Fenestellidae and Spiriferacea (?). One piece of blue-grey rock composed almost entirely of bryozoans and resembling the Granton Limestone was found inland along the strike. However it was not *in situ* and no more could be found in the thick scrub and soil cover of this area.

Conformably over this is a bed of silicified felspathic quartz-conglomerate containing no fossils. Then follows a thin bed of siliceous siltstone which is also unfossiliferous. Over these beds is a highly fossiliferous mudstone now completely weathered to clay. It is white when dry but, on first digging it out, it has a green colour. The rock is composed mainly of bryozoan molds and has been correlated with the Grange Mudstones.

The next beds to be seen have been weathered to clay but this fine matrix carries nodules and bands of pebbles and cobbles. The larger particles occur with the haphazard distribution typical of a tillite. This weathered material grades up into a massive, medium to coarse grained quartz sandstone. The sandstone contains many tubular plant stems. These appear as carbonaceous films filled with sandstone but show no structure. Another feature of this sandstone is the many iron stained nodules that stand out on the weathered surfaces. Erratics of quartzite, schist, and slate pebbles up to 1″ in diameter are common.

On the western shore of Chale Bay down which no faulting of any magnitude could be detected, a bed of very coarse quartz sandstone or granule conglomerate outcrops in a cliff. This bed from its stratigraphic position corresponds to the Risdon Sandstone but shows unusual features. Truncated current bedding and contemporaneous faulting occur in some beds. The following section has been observed about half a chain from the point at the head of the Bay.

Adamson Run 5 Photocentre 25272 distant 1·1″ Bearing 219°

6″ thin sandy grey soil.

5 ft. white conglomerate containing angular quartz and felspar. Coarser bands (current bedded) lie at oblique angles to the finer bands.

6″ fine shaly material weathering to a brown dust.

1 ft. coarse sandstone with iron stained nodules.

2″ finer sandstone grading from coarser at the bottom to finer at the top.

2′ 6″ light brown sandstone with iron stains and coarse current bedding.

1′ 6″ fine carbonaceous sandstone and shale containing mica and indistinct plant remains on the bedding planes. The top 2″ of this bed becomes pebbly.

2′ 6″ brown conglomerate containing quartz and felspar pebbles up to ¼″ diameter. It is current bedded and is jointed independently to the overlying beds.

6″ The downward extension of this bed is below water level. It is a conglomerate containing sub-angular quartz up to ½″ diameter with some felspar of ¼″ diameter.

The dip of these beds (2 deg. to 285 deg. (mag.)) is the same as that of the Eastern shore of Chale Bay.

The section outlined is conformably overlain by a fine quartz sandstone with subordinate felspar and occasional erratics of granite and quartzite up to 1 ft. in diameter. This occurs in massive unfossiliferous beds and is thought to belong to the Ferntree Mudstone Formation. As heavy jointing occurs throughout the area, the jointing near this contact is not thought to constitute a fault upthrowing the Woodbridge Formation beds, which, in the Hobart area except for the lack of fossils, resemble this bed. Moreover these unfossiliferous beds continue westward to the contact with the dolerite beyond Raminea. Here the topmost beds are identical in lithology with the Ferntree Mudstone of other areas.

The maximum dip recorded in this area was 6 deg. in a direction 29 deg. (mag.) so that the total thickness between the dolerite intrusions would be at a minimum 350 ft. and at a maximum 800 ft. (taking dips as 2 deg. and 6 deg. respectively). Of this thickness about 7/10ths is in Ferntree Mudstones leaving at the most about 250 ft. for Woodbridge, Grange, and part of the Granton Beds.

The above section is not an entirely satisfactory one for this purpose because large parts of the succession have been obliterated by weathering while the waters of Chale Bay and the Esperance River cut across it.

A much more complete section which however is not so thick stratigraphically is found on the opposite bank of Esperance River. This section may be laterally contiguous with the last one, or there may be some small break parallel to the course of the river here.

The beds dip at 5 deg. in a direction of 304 deg. (true) and the top of the Permian beds pass up into the Triassic Sandstones but the exact relation of the two systems cannot be determined along this boundary. Beneath, the beds are intruded by dolerite with some baking. This contact is at 2·5″ bearing 146 deg. from photocentre 25272 Adamson Run 5.

The bottom 90 ft. is composed of a coarse quartz sandstone varying from light olive grey to dusky yellow in colour. Some white mica, felspar, and subordinate iron-stained clay cement compose about 20 per cent of the rock. The remainder is of angular quartz varying from 0·1 to 0·01 inches in diameter. Some fragments of slate were seen of about ·01 inches in diameter. Iron staining is common and the bedding is massive. The quartz is of the vitreous, milky, and blue varieties and suggests a metamorphic provenance. This coarse sandstone is interbedded and interdigitated with finer sandstones and siltstones as well as at least one band of a coarse tillitic conglomerate.

Although no striated pebbles were found, faceted boulders (up to 1 ft. in diameter) of grey and red granite, quartz, quartzite, and slate are scattered haphazardly throughout the beds, often causing indentation in the underlying bedding planes. These indicate a glacial origin.

A bed of conglomerate about 3 ft. thick occurs at 1·5″ bearing 146 deg. from photocentre 25272 Adamson Run 5. This is unfossiliferous and carries numerous boulders of the above-mentioned rock types in a coarse sandy matrix.

Above this bed, the rocks become gradually finer grained lenticular beds of fossiliferous mudstone of creamy white colour carrying abundant bryozoans as well as small molluscs and brachiopods. These beds gradually become coarser again and the felspar content increases.

All the above beds, with the exception of the conglomeratic bed, are richly fossiliferous. In the coarser beds, the fossils are large and include *Platyschisma, Stenopora, Aviculopecten,* various large Spiriferacea, *Mourlonia* (many), other brachiopods mainly spiny productids, Fenestellidae, and, in patches, abundant crinoid ossicles. In the finer layers, these fossils occurred but are smaller in size and are outnumbered by the Fenestellidae which give the rocks a laminated appearance. Nowhere was the original calcareous matter seen; all the fossils are molds. No ostracods were observed in this area.

Conformably over these beds which grade imperceptibly into it there is a light mottled tillite between 20 and 50 feet thick. The bed shows no internal bedding but is cut by webs of limonite, particularly near sea-level. The grain size varies from boulders 3 to 4 ft. in diameter down to clay. Some sorting is apparent for the boulders and pebbles are often found in clumps and stringers showing that water transport had been partly responsible for this deposit. No fossils have been found in these beds.

The coarse constituents are sub-angular to sub-rounded and all show faceting but no clear striations were seen. The larger particles included quartz, quartzite, schists, slate, grey and red granites, and pink quartz. Some fine sandstones occur throughout the deposit. The lack of bedding,

extreme variation of grain size, faceting of pebbles, the uneven distribution, and poor sorting are evidence that this bed was formed under glacial conditions.

These beds weather easily and deeply, especially the sandy patches, to yield a clay rich in very angular quartz particles. The clay may be largely derived from the felspar and mica content of the original rock. This bed has been correlated with the Woodbridge Glacial Formation.

Succeeding this is a 20 ft. bed of coarse sandstone and granule conglomerate composed of quartz and felspar, with subordinate tourmaline, mica, and dark minerals. When fresh, the rocks are brown but when leached are usually white, or, if iron stained, cream or reddish yellow in colour. They are easily weathered yielding a coarse white sand or, if in a water-logged locality, a yellow sandy clay. The felspar content is usually about 25 to 30 per cent and weathers to kaolin before being completely removed. After the clay is removed a porous friable white quartzose rock results.

There is no definite break in the grain size or type of sedimentation to be seen at the base of the beds. The grain size is similar to the underlying beds but the clayey material has been sorted out. The boulders, cobbles, and pebbles are quartz, usually milky but with some blue quartz pebbles. The finer material includes vitreous angular quartz and felspar fragments, slate, schists, and quartzite. The exposure of these beds is not as clear on the southern river bank but the lithology of the rocks is similar. From their stratigraphic position, they are correlated with the Risdon Sandstones.

The grain size declines gradually upwards into the medium to fine, white, red, or yellow sandstones of the Ferntree beds. In these, the fine matrix increases but quartz with some felspar is predominant. The basal beds carry sub-rounded, milky, and clear quartz pebbles up to $\frac{1}{4}''$ diameter in a finer matrix. The texture in these lower beds is similar to the underlying beds. Boulders of granite and quartzite up to 1 ft. diameter occur more frequently in this area than in the Hobart district. Higher in the sequence the typical blue-grey mottled mudstone carrying few erratics up to about 3″ diameter appears. The highest material seen in this locality was a fine sandstone similar to that just over the Risdon beds.

The thickness of the Ferntree here is about 400 ft. which is approximately the same as that in the sections along the Huon river. It will be realised from this that the Permian beds here do not match the Hobart area sequence but it is essentially the same as that described by Prider at Marlborough.

Thus the lowest beds at Folkestone would correspond to the Grange and possibly the top of his Granton facies of the Marlborough Series. The next beds cannot be distinguished here but, on the northern bank, the beds between the dolerite and the Ferntree mudstone are similar in every respect to his Bronte facies. His Woodbridge Formation is similar in that it is of glacial origin, contains the same type of erratic and, in particular, is unfossiliferous, but it is much thicker than at Dover. It is realised that the lower beds of these two sections may be part of the Woodbridge Glacial Formation in which the biofacies has changed as well as the lithofacies. The problem of whether this sequence is part of the Grange or part of the Woodbridge Formation cannot be solved in this area without drilling. In either case, it would be necessary to specify

some change of facies. In this paper, the tillitic horizon will be referred to as the Woodbridge Glacial Formation and the beds below that will be called the Grange Mudstone.

Although the Risdon Sandstone is persistent enough to warrant the rank of a formation, the normal usage of including it as a member in the Ferntree Mudstone will be followed. This name, Ferntree Mudstone, will be applied to all the Permian rocks lying above the Woodbridge Glacial Formation and below the Basal Grits. This is possible because here the Cygnet Coal Measures do not appear to have survived the erosion that followed the deposition of the Permian beds.

Grange Mudstone

The beds along the lower Esperance River are the coarse fossiliferous sandstones as described in the section above having similar variations of colour and grain-size, and carrying the same fossils.

The beds on the shores of Port Esperance are finer-grained, being orange-yellow mudstones sparsely fossiliferous. The fossils are mainly *Stenopora* with a few spirifers, gastropods and pelecypods. Erratics occur in both outcrops. Both types are highly jointed. The jointing becomes more intense and the dips more variable as the dolerite is approached. The baking effect of the dolerite extends for less than ten feet from the contact and in places for only two or three feet. The mudstones and sandstones weather to a white or cream clay.

The micro-and-macro characteristics of these beds indicate that they were formed under glacial conditions in water of medium depth. The detritus was shed from a provenance containing metamorphic and acid igneous rocks.

Woodbridge Glacial Formation

This name, as mentioned above, will be confined to the relatively thin bed of tillitic material lying conformably between Risdon Sandstones above and the Grange Mudstones below. As shown on the map it outcrops on the eastern shore of Chale Bay and across the land lying between the Esperance River and Hopetoun Beach. No other outcrops occur within the area but the formation was recognised at nearly 2,000 feet above sea level on the track to Adamson's Peak where it forms a low cliff.

The characteristics of beds given above show that the material was derived from the same provenance as the underlying beds but that the glaciation had become more intense.

As well as the coarse conglomeratic phase, there are large areas of sand grade material with subordinate erratics. Both types weather to a sandy clay of variable colour. The best exposure of these beds is found along the foreshore between the northern end of Hopetoun Beach at Adamson Run 5 Photocentre 25273 distance 1·2″ bearing 57°, and the slips at distance 1·9″ bearing 57° from the same centre.

Ferntree Mudstone

The basal member of this formation is to be seen overlying the Woodbridge throughout the Permian belt around the mouth of the Esperance River. It is well exposed on the western shores of Chale Bay

and at Adamson Run 5 Photocentre 25273 distance 1·9″ bearing 57°. At the latter locality its relation to the underlying Woodbridge can be clearly seen.

The Woodbridge tillitic beds grade with no perceptible change of grain-size of the sandy portions into the Risdon. But the character of the erratics change so that in comparison to the mixed rock types of the lower bed, the larger Risdon erratics are overwhelmingly quartz or quartzite; pebbles of slate and other fragments are of small grain size (i.e., 2-4 mm. in diameter or less). The sorting has been more thorough in these beds so that less clayey material occurs.

The beds here are between 20 and 30 feet thick and show the characteristics described in the two sections along the Esperance River. The band containing carbonaceous material seen at the Chale Bay also occurs near the slips (co-ordinates given above).

With declining grain-size and an increase in the clay grade material these beds grade into the overlying sandy mudstones or fine sandstones.

The Risdon does not outcrop again in the area but the higher Ferntree beds are well developed along the north of Port Esperance and along the western shore of the Huon River. Another isolated occurrence is at Folkestone and along the Dover Rivulet.

Folkestone

The Permian rocks in this area are divided by a dyke of dolerite. Those to the north-west have been dealt with already, but the rocks to the south-east of the dykes have not been so well exposed and their exact stratigraphic position fixed. The sediments are completely enclosed in dolerite and show some, but not widespread, baking along the boundaries. No fossils have been found in this area and the outcrops along the river bank are weathered to clay, thus obscuring the succession there.

At Adamson Run 5 Photocentre 25273 distance 2·9″ bearing 210° some very soft green-stained yellow clayey material contains pebbles of quartz, sandstone schist, and granite and may represent the weathered outcrop of the Woodbridge Glacial Formation. However the greater part of this locality is occupied by grey, and mottled grey and white fine sandstones or argillites containing some erratics most of which are less than 2″ in diameter.

A quarry at Adamson Run 5 Photocentre 25273 distance 4·4″ bearing 214½° is in a mottled grey-white to brown and yellow rock. The beds show a rhythmic alternation of sandstone and argillite bands, the thickest of which is about 2′ 6″. A few rounded quartzite pebbles of 2″ diameter were seen. The south-western side of this boundary has been hardened by the dolerite which intrudes these beds along a very irregular contact down to the mouth of the Creekton Rivulet. These beds are considered to belong to the Ferntree Mudstone Formation.

The Ferntree Mudstone of the rest of this Esperance River section, i.e., west of the dolerite shows the following characteristics. The lower beds are quartzose sandstones carrying many angular erratics up to 18″ in diameter (usually quartzite). These erratics tend to be found in clumps. The bed at the southern abutment of the Raminea bridge is typical of this phase. Some indefinite plant remains occur.

This coarse phase is succeeded by an argillite which is rhythmically bedded—the beds showing slight changes in grain-size but only few and thin layers become shaley. Large concretionary structures 3 to 4 feet in diameter are common in some beds. These beds are typically blue-grey and white, mottled rocks with very small erratic pebbles and no fossils. They are well exposed in quarries at Adamson Run 5 Photocentre 25270 distance 0·4″ bearing 180° and distance 3·25″ bearing 76½°. The beds above these are not very well exposed but they tend to be sandier towards the top of the succession as at Run 5 No. 25273 distance 3·2″ bearing 307°.

Dover Area

The Risdon Sandstone grades out of the Woodbridge Glacial Formation near the jetty and slip at Adamson Run 5 Photocentre 25273 distance 1·9″ bearing 57°. The contact here, as well as it can be delineated between very similar beds, runs beneath the jetty. The Ferntree continues in the mode of a medium to coarse sandstone with some mudstone along the shoreline until it is succeeded by the Basal Grits at Adamson Run 5 Photocentre 25276 distance 4·5″ bearing 40°.

The coarser beds at sea-level are grey with prominent yellow-grey bands up to a yard in width outlining the many vertical joints. Erratics of quartzite, slate, and serpentine up to 2 feet in diameter are fairly common. These beds are massive. Some bands are almost entirely composed of cobbles.

From about 10 feet above water-level, the bedding becomes less massive and erratics fewer. These argillites—the grain-size has decreased too—are mottled and grey in colour. The rock type continues upwards until overlain by dolerite. All these beds weather white or yellow.

The succession to the east is covered by sand-banks or detritus so that the exact transition into the Basal Grits cannot be followed. However beds which may be portion of the Cygnet Coal Measures consist of blue-grey or greyish-yellow carbonaceous sandy shales with abundant mica on the bedding planes. Current bedding and concretionary structures are usual. Bands of carbonaceous matter occur throughout but no fossils were found here. The contact with the overlying beds is undulatory and probably constitutes a disconformity.

Stanmore

" Stanmore " homestead is situated at Adamson Run 3 Photocentre 25273 distance 1″ bearing 200°. The rocks outcropping along the road in this vicinity are the typical mottled or grey argillites of the Ferntree Mudstones. The beds are succeeded in the vicinity of the road junction south of " Stanmore " by the Triassic sandstones. To the east the same sequence is observed until at the distance 1·1″ bearing 146° from the same photocentre, the dolerite has intruded and displaced the sandstone.

The exact location of the boundary between the Permian mudstone and the Triassic beds could not be located accurately because of cultivation and soil creep. It is probable that the lower beds of the Permian occur northward along the road but thick detritus from the dolerite and deep weathering combined with the lack of fossils prevented the establishment of this in the mapped area.

Police Point Area

The Ferntree beds in this area outcrop beneath the Basal Grit at Adamson Run 2 Photocentre 2955 distance 3″ bearing 175° and can be followed on very good exposures along the shore to a distance of 0·5″ bearing 220° from the same centre point where it is transgressively intruded by dolerite. A barometer reading taken on the hill to the west of this point gives a thickness of between 300 and 400 feet here. The intense jointing of the beds right along this shore reduces the usefulness of these sections in obtaining thicknesses. The beds dip at 5-6° to 150° (mag.).

As at east Dover, the topmost beds are in carbonaceous, black, grey, and yellow shales carrying much mica. No fossils were found and erratic pebbles are missing. The beds are replaced downwards stratigraphically by massive black mudstone containing indefinite plant stems. The beds are not micaceous and contain quartz pebbles.

Below these the normal type of Ferntree mudstone, grey or mottled, weathering to yellow or white, and containing weathered erratic pebbles gradually appear in the usual rhythmic succession of massive beds. Shaley bands occur, usually of dark-grey colour, but are not so abundant as at Claremont.

The weathered surfaces of the beds are very pitted and irregular. They show indefinite fossil impressions that appear as little convoluted piles on the surface and may represent worm casts. In some beds extending over considerable distances and at different stratigraphic levels indefinite plant stems appearing as circular to oval occasionally branched, notched and, in a very few places, striated pipes are to be seen in considerable numbers.

In other beds large concretionary structures as much as six feet across by two or three feet in height having a flattened spheroidal shape occur in large numbers. These occur at several stratigraphic levels and are especially well developed at Adamson Run 2 Photocentre 2955 distance 2·15″ bearing 181½°. Here they can be seen at all stages of destruction. The walls are usually about 6″ thick and tend to be iron stained but the beds are too structureless to see if the bedding continues through the concretion or not. The walls appear to be enriched in silica giving a case hardened effect that resists weathering more than either the interior of the concretion or the surrounding rock. Cracks cut the walls into various shaped fragments which wash out piece by piece under wave action. The interior of the larger ones are intensely current-bedded and of finer material than the walls although occasionally the reverse is true. Webs of limonitic material traverse this material. In one or two small ones about 1″ in diameter, segmented casts possibly of a plant were seen.

Along the prominent point due south of the centre of Run 2 No. 2955, at a distance of 1·7″, a band of hard conglomerate occurs in these beds. This rock is composed of sub-angular to sub-rounded tabular pebbles, cobbles, and boulders up to a foot in diameter of quartz (predominant) quartz schists, quartzite, sandstone, or mudstone. No granite was seen and the quartz is clear or milky. The finer portion is predominantly quartz, vitreous and angular. The rock is cemented by clayey material and fresh surfaces are a creamy-white colour. The bed is 3 feet thick and conformable with the beds below and above.

White Bluff—Brook's Bay Area

(Adamson Run 2 Photocentre 2953 distance 3·0″ bearing 343°)

In this area the Permian rocks occur in a precisely similar manner—Basal Grits on top of the sandy shales which grade down into the massive carbonaceous beds. These in turn are replaced by the mudstone beds carrying scattered erratics, concretions, and, in this locality, some specimens of silicified wood were obtained. The fossil plant remains (fucoids of R.M. Johnston) are very abundant, but, as with the structures resembling worm casts, the preservation is too poor to allow identification.

Ferntree beds extend from the above point to Surges Bay but the dips are variable (at Brookes Bay it is 12° to 209° (true)) and the beds are interrupted by at least two injections of syenite porphyry so that the thickness which has been estimated at between 300′ and 400′ can only be put forward as an indication of the order of the thickness.

A piece of fossil wood obtained from south of the Brookes Bay Jetty (Picton Run 14 Photocentre 22085 distance 4·2″ bearing 18°) was forwarded by M. R. Banks to Dr. Mary Calder of the University of Manchester from whose reply to Banks the following extract has been taken.

> "No. 20889 Ferntree Mudstone . . . . shows fine structural detail of a coniferous wood, almost undoubtedly *Podocarpaceae*—I should be *most* surprised to find Podocarpaceae in rocks as old as Permian".

She also stated that it was related to the living genus *Phylocladus*.

Banks determined from literature that the lowest age limit of this genus is Upper Triassic and, after visiting the area and agreeing that the rocks undoubtedly belong to the Ferntree Mudstones, has sent another piece of the specimen to Dr. Calder to act as a check.

This is the only indication of the age, of the Ferntree beds in this area. In the Cygnet district though, the overlying Cygnet Coal Measures carry such Permian plant fossils as *Gangamopteris spatulata, Glossopteris Browniana* var. *praecursor* and *Vertebratia australis* which establish these beds as Permian in age.

Summary of Permian Stratigraphy

The Permian rocks in this area are conglomerates, sandstones, siltstones, and claystones. Sandstones predominate and are characterised by the poor sorting of the constituent grains. The mineral fragments are usually extremely angular reflecting the glacial conditions which are further emphasized by the presence of fresh felspar in all these beds.

The dominant mineral, plentiful even down to grain-sizes of ·5 μ as proved by X-ray studies on residual clays, is quartz. It is angular, often shows undulatory extinction, and is, dominantly, a clear vitreous variety although milky and blue quartz is often seen. Felspar reaches a maximum of 30 per cent in few places. It is found both fresh and weathered. One determinable specimen from the Risdon Sandstone was found to be andesine. Mica (usually muscovite) was seen in all specimens and was not confined to the bedding planes. Tourmaline, zircon, pink garnet, rutile, and pyrite were among the minor constituents. Clays where determined were found to be kaolinite with a small percentage of illite.

These minerals together with the erratics show that it is probable that these sediments came from a low-lying glaciated provenance containing metamorphic rocks, acid plutonic rocks, and serpentine. The evidence from this area supports the conclusion of Banks (1952) that the Permian beds belong to an ortho-quartzite-limestone suite and that no vulcanism took place during their deposition.

It can be inferred that the intensity of glaciation reached a maximum during the deposition of the Woodbridge glacials with minor peaks during the Grange and perhaps Ferntree times followed by a reversion of glaciation until finally the Cygnet Coal Measures were deposited under moist cool temperate conditions. It is possible that the solitary conglomerate band in the Ferntree indicates not an increase in glaciation but a response to either orogenic movement elsewhere or to an isostatic readjustment following the removal of the ice load.

During the deposition of these beds, on a stable to mildly unstable shelf, the water was fairly shallow and cold with the depth of the sea responding closely to the intensity of glaciation. However even the Ferntree mudstones were deposited in fairly shallow water. The Cygnet Coal Measures represent a rise in land level which is reflected in the increased coarseness of the rocks at the top of the Ferntree and in the sandstones of the Coal Measures themselves. Lacustrine, swampy conditions prevailed during their deposition.

THE TRIASSIC SYSTEM

Although Triassic rocks outcrop over large parts of the area and fairly complete sections of them are present, there is no place in which it is possible to see all the rock types. The shales rarely outcrop and are usually found as fragments in creek beds or in landslides and the highest beds appear close under the dolerite the scree from which frequently covers them. Inland, all the Triassic rocks tend to weather deeply and usually carry a thick vegetation.

The beds, wherever the succession is clear, begin with the Basal Grits which lie disconformably over the truncated Cygnet Coal Measures and in every outcrop are cut off by a dolerite intrusion which usually cuts through the Felspathic Sandstones. No age determination could be made from this district.

In contrast to the Permian rocks, these beds are very similar to the Triassic rocks of the Hobart area both in composition and in sedimentary structures. Current bedding, unilateral rolling strata, symmetrical current bedding, concretions, contemporaneous erosion and faulting are common wherever the lower beds appear. The higher beds are not well enough exposed to examine them for these features. The shales are usually ripple-marked and the slump structures and current bedding indicate that the direction of current flow during deposition was from the north-east.

"Basal Grit"

This name is applied to a bed of granule conglomerate or coarse sandstone usually about 15 feet thick but somewhat variable in its development that lies with slight disconformity on the eroded Cygnet Coal

Measures. No striking disconformity is seen because the sedimentary structures and minerals of both formations are very similar but there is a distinct difference between these and the Ferntree Mudstones.

The main evidence for disconformity is the inclusion of boulders of Ferntree Mudstone in these beds at Police Point. This evidence is supported by the undulating contact with the underlying shales, the vast increase in heavy minerals, by the inclusion of at least one conglomerate band in the grits, and the increased coarseness of all bands.

The conglomerate band which may or may not lie on the undulatory contact consists of pebbles and cobbles of quartz, quartzite, slate, schist, and mudstone. The interstices between the pebbles are filled with angular quartz very lightly cemented with clay resulting in a rather friable rock. This band varies from 6 inches to 1 foot in thickness but is often missing from the sequence.

The finer material in the Grits is a cream to white but often iron-stained sandstone varying from fine to coarse in grain-size. The sandstone is lightly cemented and composed mainly of angular quartz. It is current-bedded but no slump structures were seen. Lines of pebbles often outline the current bedding.

Quartz, usually vitreous and of metamorphic origin but sometimes milky or blue, makes up about 60 per cent of the rock. Felspar is usually present but often is kaolinised and is never greater in quantity than 10 per cent. Biotite, muscovite (more abundant) and graphite are common. Tourmaline, rutile, topaz, limonite, and a black spinel have been identified from the heavy fraction but the most distinctive mineral is the pink to red garnet that occurs as patches or stringers at almost every locality examined. Some garnet occurs in the Permian rocks but the vast increase here suggests that erosion in the source area had uncovered the garnetiferous schists of the Pre-Cambrian rocks which carry this type of garnet. Epsomite occurs near Police Point.

The shape of the mineral grains and the presence of mica suggests that deposition took place close to the source area in a shallow or near shore environment.

Knocklofty Sandstones and Shales

The beds of quartz sandstone and shale that conformably overlie the Basal Grits in every locality are given this name to avoid the confusion caused by the terms Springs Sandstone and Ross Sandstone. At Brook's Bay the estimated thickness is from 400-500′.

They occupy most of the area mapped as Triassic and have distinctive physiographic expressions. On dip slopes extensive button grass plains are found which consist of ridges carrying a poor eucalypt flora separating large swampy areas. Along the coast steep marine cliffs up to 300 feet high are formed wherever they are found. Inland, cliffs up to 200 feet high are found to form in a massive quartz sandstone which occurs about 150 feet above the base of the formation. Another common feature due to the failure of the shales exposed to moisture are the numerous landslides.

These beds are characterised by their abundant sedimentary structures. They are composed of interdigitating sandstones and shales but these beds do not occur in the same order from area to area. The bedding

may vary from fissile in the shales to massive in the sandstones in which current-bedded and massively-bedded layers interdigitate and alternate. The massive beds usually weather to a coarse honeycombed surface. Concretionary structures are common in all the coarse beds ranging from iron-stained nodules to large structures a yard in diameter. None of the long cigar-shaped concretions seen elsewhere in the System were developed here. Another noticeable feature is the presence of numerous mud-pellet conglomerates seen throughout. The pellets which are usually flattened oval-shaped structures up to 6 inches long and dark cream in colour weather out to leave a characteristically shaped void in a white sandstone. In some places, particularly near Red Cliff, inclusions of Knocklofty shales and sandstone in these clay-pellet beds indicate contemporaneous erosion.

The colour of these sediments is variable. Red, black, brown, green, and purple shales were seen, e.g., red and purple shales outcrop towards the top of the formation at the southern end of the Raminea Plain. The sandstones are white, brown, green, stone, purple, mottled, and, if iron-stained, orange in colour. The sandstones usually weather to a white or yellow colour finally yielding a white or yellow fine sand.

The predominant mineral is quartz which, in the sandstones, commonly constitutes more than 90 per cent of the rock. Silica and iron oxides are the usual cements. Felspar is present at most levels but never constitutes as much as 10 per cent of the rock. Mica, mainly muscovite, and graphite are common especially on the bedding planes of the shaley beds. Some mica is usually scattered throughout the sandstones but very few heavy minerals occur. The quartz is usually vitreous and angular often showing regeneration causing the sparkling effect given by many of the sandstones. The mineral content of the shales has not been examined. In contrast to the underlying beds, the sorting in this formation is very thorough resulting in very even grained beds.

A common feature is the occurrence of lenses of carbonaceous shales found in the massive sandstones as at Red Cliff. The bands are about 6″ thick and of variable extent. The distribution is irregular suggesting that they were formed in small swampy parts of a dune landscape.

A bed not previously reported from this area occurs on the top of hillocks in the south of the Raminea Plain and more extensively just below the " Felspathic " sandstones to the west of Police Point. It is a bed of quartz conglomerate and coarse sandstone whose most distinctive feature is the presence of pebbles of pink quartz as well as the more usual milky quartz. The quartz pebbles usually about $\frac{1}{2}$″ but occasionally up to 2″ in diameter are tabular and sub-rounded. The colour is usually brown-grey to light grey but all examples seen had been exposed and have porous appearance suggesting that some minerals (felspar) has been leached out. On Raminea Plain this bed appears to be about 15′ thick but the amount that has been eroded could not be checked.

These beds were probably deposited in a lake or lakes which periodically dried out. Saline deposits indicate for the lower part a hot, dry climate while the carbonaceous matter probably indicates rather moister conditions at different levels. A slowly sinking floor is indicated by the sorting and sedimentary structures. The minerals present which indicate

by their physical properties that all these sediments were transported by water, suggest that the sediments came from a low terrain containing metamorphic, acid plutonic, and Permian rocks.

"Felspathic" Sandstones

These sandstones do not occupy extensive areas in this district. They outcrop over the Knocklofty Sandstones and Shales but the nature of the succession or the exact location of their base cannot be determined.

It is considered however that the base of this formation lies in the thick belt of cream or yellow plastic clay that occurs in all the localities that have any felspathic sandstones. The formation is overlain by transgressive dolerite sills so that the topmost beds cannot be accurately determined. Green-grey and brown claystone, the latter carrying plant fossils, white quartzose sandstones containing stringers of carbonaceous matter and a yellow micaceous sandstone have been observed in this formation at various localities. The coal seen at only one locality is associated with the brown shaley claystone.

The sequence here is considered to be:—

Dolerite
Felspathic sandstone
Claystone with coal
Quartz sandstone
Clay bed
Knocklofty Formation

However the succession is far from clear and the thick cover of vegetation and weathered rock prevented clarification of this. No dips could be obtained and therefore no thicknesses could be estimated.

The specimens examined were found to be rather porous rocks that showed no effervescence with acid although in thin sections from other areas calcite is very abundant. Here apparently it has been leached out leaving voids.

A thin section of the "Felspathic" Sandstone from the Green Hill area shows that the rock is very similar to specimens from Old Beach and New Town. However, whereas in the above areas the fragments are always very angular and shattered, the Green Hill sample shows subrounded to rounded particles as well as a considerable amount of irregularly crystallized interstitial biotite which is probably due to the effect of the nearby dolerite. Although there is considerable variation in grain-size from place to place, all these sandstones are well-graded. The average grain-size of this specimen lies between 0·2 and 0·5 m.m. The approximate amounts of constituents are as follows:—

	%
Rock fragment	40
Feldspar	20
Quartz	10
Matrix	20
Accessories (mainly micas)	10

The rock fragments are made up of about equal amounts of fine-grained igneous material which appears to be trachytic and a mixture of quartzitic, cherty, and granitic particles. It is difficult to give a name to this rock at present beyond calling it a tuffaceous sandstone but work being carried out at the present time may lead to a more definite classification.

Although a complete heavy mineral analysis was not carried out, pink garnet, tourmaline showing clean uncorroded surfaces, and a dark, opaque, non-magnetic mineral, probably ilmenite, were observed. The garnet, particularly, implies that the provenance of this sediment is similar to that of the lower Triassic beds.

Strathblane Plain Area

The whole South West corner of the mapped area is underlain by Triassic sediments. The main button grass plain from the Old Hasting Road westwards to the forested hills on the other side of the Creekton Rivulet is occupied by the Knocklofty Sandstones and Shales. This formation extends beyond the road to the east near the centre of Adamson Run 8 No. 2972. This break in the dolerite is occupied by Triassic sediments to beyond the boundaries of the area.

Along the Old Hastings Road there are a few exposures of quartz sandstones and siliceous shales but over the rest of the plain no outcrop could be discovered. Except in the north where in the deep cuttings on either side of the Creekton Rivulet some weathered quartz sandstones of brown and white colour can be seen, even the cuttings through the ridges reveal only sand. This sand may be alluvial but it is more probable that it is weathered sandstone about 10′ deep.

The test pit at Adamson Run 8 Photocentre 2974 distance 0·4″ bearing 300°, although full of water, yielded some fragments of quartz sandstone but the fossil impressions reported by A. McIntosh Reid (1922) have weathered away.

Towards the south, the same beds outcrop and are deeply dissected by the creeks flowing towards Southport. The track running west from F.D. 1 8 which is south of the mapped area shows the following succession under the dolerite:—

Knocklofty Shales and Sandstones in white quartz sandstone and shales.
White quartz sandstone of fragile appearance and carrying carbonaceous streaks.
Yellow micaceous sandstone.
Fine grained dolerite.

From the test pit mentioned above going south-west along the old tram line, the sandy soil is replaced along the edge of the thick vegetation by a wide bed of cream and yellow clay which continues along the main tram line to beyond the area.

This clay bed continues up the track to the north until dolerite which appears to be a dyke intrudes it. After crossing the creek which flows along the face of a dolerite cliff, the Felspathic Sandstone is encountered. An exposure in the creek bed shows that it is lying over a fine-grained dolerite contact. Somewhere in this area the main workings of the Strathblane Coal Mine were put down but the vigorous regrowth of scrub prevented the location of this mine. The coal seams here were located in felspathic sandstones. The presence of boulders of dolerite in the deep soil on the western slopes of the hill on which the coal mine is situated suggests that the top of this hill is in dolerite.

The section along the track running west from the bridge over the Creekton Rivulet at Adamson Run 8/2973 distance 2·9″ bearing 33° showed quartz standstones to the edge of the scrub, a clay bed until the

first major bend in the track, then a fine quartz sandstone followed by a gap with no outcrop. At the next major bend in the track, a tunnel (now collapsed) has been driven along a coal seam immediately below a fine-grained dolerite contact. The spoil heap reveals specimens of brown clay stone with plant fossils and anthracitic coal with a hackly fracture. The shale and coal have been intensely slickensided.

Beyond the dolerite sill, the Triassic sandstones are found to outcrop from the valley at Adamson Run 8 No. 2975 distance 2″ bearing 351°, to beyond the junction of the tracks at Adamson Run 6/25294 distance 3·9″ bearing 323°. The northern portion of this track is in quartz sandstone which resembles the Knocklofty Sandstones by the manner in which they form small cliffs along the creeks.

As far as could be ascertained the sediment lying between the Creekton Rivulet and Green Hill is part of the Knocklofty Formation.

Raminea Plain

Here quartz sandstones showing current bedding, slump structures and the voids from which clay pellets have been weathered lie under the dolerite and form an undercut cliff 100 feet high along the eastern bank of the Esperance River. The sandstone reaches a height of 410′ above the river level. At this level, a coarse brown sandstone outcrops.

Along the Esperance River towards the north, shales and sandstone of this formation may be seen in the river bed beneath alluvium. At the Adamson Run 4/25181 distance 2·2″ bearing 296½° the green siltstone which occurs at Police Point outcrops.

Above this the clay beds intervene and are covered with fine-grained dolerite wherever access was obtained. This clay bed with its heavy vegetation is seen along the old tram line between the Adamson track and Big Creek on the western edge of the plain. This hill is capped with dolerite as is the hill to the south of the Adamson track.

The Green Hill track section shows a break in the dolerite at the head of the valley at Adamson Run 5/25265 distance 3·2″ bearing 155°. The most pronounced valley here shows dolerite over shaley claystone to the east with a fault down the valley which upthrows to the west so that the western dolerite stands 100 feet higher. From the valley, shales are followed by Felspathic Sandstone over which lies the dolerite.

Further west two more chilled contacts between the Felspathic Sandstone and the dolerite occur. West of the last outcrop of dolerite the track runs over quartz sandstones. This is continuous along the track to the Strathblane Plain.

Hopetoun Road Area

Here the base of the succession has been covered with landslide detritus so that the first beds to be observed are dark brown micaceous coarse sandstone. These are succeeded by lenticular beds of shale and sandstone outcropping in the cuttings along the road at Adamson Run 4/25177 distance 1·9″ bearing 172°. Quartz sandstones succeed to the border of the area. Similar beds continue westward from here to the Esperance Road along the north of Burns' Hill. Considerable cliffs are formed along the creeks in the massive quartz sandstone.

The scarp behind Francistown is in quartz sandstone interbedded with shales that form step-like flats. The clay pellet conglomerate is well developed about half way up this cliff.

Dover Area

A completely isolated pocket of Triassic sediment in the dolerite occurs along the Dover Rivulet. It is covered to a large extent by alluvium and dolerite scree. At Adamson Run 4/25175 distance 2·6″ bearing 108½° a few fragments of garnet bearing conglomerate were observed in a contact zone that has been furrowed with adits, costines, and prospect pits. At Adamson Run 4/25175 distance 0·7″ bearing 77° a brown ripple marked micaceous shale typical of the Knocklofty Beds outcrops.

Stanmore Area

The Triassic here consists of quartz sandstone and shales. The sandstones are covered with a thick cover of sand. Against the dolerite along their southern contact a dense quartzite has been formed.

The base of the succession has been obscured by cultivation but the presence of the Basal Grit is indicated by the presence of quartz gravel.

Brooks Bay Area

This Triassic section is the most complete mapped in this area. The beds lie disconformably over the Ferntree Mudstones and are overlain by a transgressive dolerite sill.

The Basal Grits, unusual here in that no red garnet was seen, form the base and are about 20′ thick. They are followed by a bed of strongly current-bedded fine sandstone which is fine-grained, white to cream in colour, and quartzose. The joints and current bedding are strongly outlined by iron-staining.

The beds succeeding this do not outcrop except for occasional bands of massive quartz sandstone. At about 150′ above the base of the beds, a medium-grained brown quartz sandstone forms cliffs about 100-150′ high. Although the actual outcrop was not seen, the characteristic voids in white sandstone indicated the presence of the clay pellet bed in this locality. The plateau here lies over this cliff-forming bed and is in shales of variable colour and quartz sandstones.

West of the road, the clayey beds associated with this part of the sequence appear and are followed by a coarse green felspathic sandstone and green shales. The dolerite intrudes over the shales which show baking effects at Adamson Run 2 No. 2953 distance 1·8″ bearing 204°.

At Police Point Adamson Run 2/2953 distance 2·2″ bearing 42° the sandstone has under the influence of the intruding dolerite assumed a polygonal columnar jointing.

Police Point Area

From Police Point southwards along the coast, the Triassic sediments are not continuous. In every locality they are cut off in the Knocklofty Formation by the dolerite. Except in one locality, the only beds that can be seen at the surface are Basal Grits and the quartz sandstones immediately overlying them. At Adamson Run 3, 25157 distance 3·2″

bearing 31° the sandstones overlie the dolerite. The contact is most irregular and the baking intense. The joints in the sandstone are thickly lined with brown iron oxide which, as the sediment weathers, forms a net-work often ¼″ high over the surface.

The lowest beds here are siliceous shaley siltstones and fine sandstones often showing unilateral rolling strata, rolling strata, current bedding, and local disconformities. Some of the shales are carbonaceous. Ascending the sequence there follows green current-bedded sandstone and shales, a green shale carrying stringers of hard material and brown spots of iron oxide.

Succeeding this is a 10′ bed of greyish-yellow-green sandstone. This sandstone is spotted and effervesces slightly with acid. The spots are moderate brown to very dusky purple in colour and probably represent weathered siderite. White mica flakes are very common. The average grain-size is ·1 m.m. and therefore the rock is a very fine sandstone. The green colour appears to be associated with the clayey cement.

Then follows 3′ of green shaley siltstone over which lies a 2′ bed of extremely hard quartz sandstone. A thick bed of white medium grained shaley sandstone carrying a vast number of purple-brown spots and nodules follows and, in turn, is overlain by the more usual yellowish quartz sandstone of this formation.

The spotted shaley sandstone which is about 30′ thick carries large cannonball concretions. These may be as much as 3′ in diameter and usually are slightly oblate spheroids.

The bedding, along which the brown spots lie, passes through the concretions without deviation showing that they are authigenic. The brown spots also pass through the structures. The rock which is of the same grain-size as the parent bed effervesces slightly with HCl. This, associated with the colour of the spots, is an indication of the presence of siderite in these beds. This point is supported by the presence on the shore-platform of long rib-like ridges and spheroidal shapes composed of limonite suggesting that an abundant source of iron has been readily available.

A thin section cut from a concretion of 2″ in diameter shows that 80 per cent of the rock is quartz of ·1 m.m. diameter. It is sub-angular to rounded in shape but is usually cracked and shows regeneration. About 1 per cent of the slide is felspar showing multiple twinning and at least one piece of microcline. Biotite was seen although all the mica seen in hand specimen is white. Some iron-staining suggests the presence of siderite but this apparently has disappeared during grinding or has been leached out. The closely packed grains are cemented by a subordinate amount (5 per cent) of clayey white cement. Therefore these are quartz sandstones of the ortho-quartzite suite. A very similar " spotted " sandstone is figured on by F. J. Pettijohn (1949, plate 15).

The beds containing these concretions weather easily so that these structures fall from the cliff face and accumulate on the beach. On breaking up the concretions they are usually found to be homogeneous but some have a skin about 1″ thick of sandstone of the above grain-size enclosing a finer grained sandstone or siltstone.

Symmetrical current bedding shows that the current flowing during the deposition of these beds was from the north-east.

A dirty white coating on the beds here is found wherever there is protection from the rain or spray. This mineral which aids the weathering by scaling off small chips of rock was found to be epsomite and has been reported from Knocklofty beds previously by Reid (1922). It indicates a hot dry climate and shallow water environments.

From this point to Surveyor's Bay the sandstones are yellowish quartz sandstones of the usual Knocklofty type. In the numerous landslides, fragments of pink, white, and brown micaceous ripple-marked shales are found but the outcrops are very few and inaccessible.

The Surveyor's Bay beds show steeply dipping baked shales over the dolerite which outcrops continuously along the beach. In the sandy soil of the orchard here a pebble of Basal Grit was found but was not *in situ*. This outcrop is a floater completely enclosed by the dolerite.

East Dover-Roaring Beach Area

At Shack Corner (Adamson Run 4, 25170 distance 1·8″ bearing 35°) the dolerite intrudes against interdigitating lenses of quartz sandstone and grey-green, and yellow shales. The colour of the sandstone is variable. Usually it is greenish-yellow in colour but has patches of red sandstone showing a concentration of haematite. The shales are ripple-marked, micaceous, and carry black dendrites on the bedding planes.

From here to the dolerite contact at Adamson Run 5, 25279 distance 0·8″ bearing 80°, the cliffs are in massive or current-bedded quartz sandstones with subordinate carbonaceous shaley stringers. The massive beds which often show polygonal shapes produced on the surface by weathering alternate and interdigitate with the current bedded sandstone.

Where intruded by dolerite the effects of the intrusion extend for only a few inches into the sandstone and, in places, for less than an inch.

An interesting section appears on the foreshore on the eastern side of Port Esperance. Here the Basal Grits, extremely rich in garnet, are succeeded by current-bedded sandstones and these by alternating beds of green-brown shales and fine sandstones showing unilateral rolling strata and current-bedding.

Beyond the fault here, the following sequence was measured:—(No. 1 is the bottom bed of the sequence)

(1)	2′ 0″	Olive sandy shale with unilateral rolling strata.
(2)	1′ 0″	Similar bed but of lighter colour.
(3)	2′ 0″	Blue-grey shale—plant fossils found here.
(4)	3′ 0″	Grey or brown interbedded shales with a superimposed flaggy bedding.
(5)	2′ 0″	Blue-grey to green-grey shales with a knobby weathered surface.
(6)	3′ 6″	Olive-green sandy shales similar to 2.
(7)	1′ 6″	Blue-grey to green shaley mudstone similar to 5.
(8)	20′ 0″	Mixed green, brown, blue-grey and grey sandy shales.
(9)	3′ 0″	Green-grey mudstones with honeycomb weathering.
(10)	6′ 0″	Shales and sandstones of variable colour and thinly bedded. The colour becomes lighter upwards.
(11)	20′ 0″	Current bedded white to yellow massive sandstone beds showing the large honeycomb weathering.
(12)	20′ 0″	Mixed sandy shales and sandstones in 6″ beds which vary in hardness. Some indefinite plant remains were observed.

The dip of these beds gradually flattens out away from the fault zone where it is 79° to 16-18° in an easterly direction.

Bed No. 12 is followed by a sandy beach which obscures the sequence but 120 yards further eastwards, cannon-ball concretions were seen in a green sandstone. About the same distance further eastwards, the marine cliff in quartz sandstone (brown and yellowish) with occasional gritty lenses following the current-bedding continues to the dolerite boundary.

Inland along the strike from the concretionary band, the creek has cut a steep scarp suggesting that the beds in which it flows are easily eroded. If the correlation with the last area is correct this would be in the epsomite-bearing band.

The Triassic beds in this area all carry a deep cover of fine quartz sand. The patches of sandy beach in front of the section described above show red and black pockets and stringers. The red colour is due to the garnet which, in some pockets, is almost completely separated from the quartz and even most of the other heavy minerals. Associated with the garnet is tourmaline, topaz, rutile, and spinel in very minor quantities. The black sand contains abundant ilmenite and magnetite concentrated from the nearby dolerite, rutile, spinel, and a few grains of garnet. It is usually found lower down the beach than the garnetiferous sand.

JURASSIC SYSTEM

Jurassic Dolerite

The Jurassic dolerite occupies the greatest part of the land surface in this district. Large dykes and transgressive sills spreading over the sediments are the usual forms found. In the area, there are some smaller areas of a few acres in extent completely surrounded by sediment but their exact relation to the sediments could not be determined. They are extremely fine grained and usually much jointed. The most feasible explanation for their presence is that they are outliers separated by erosion from the larger masses.

The highest elevation reached in the dolerite, except in the obvious fault blocks of Adamson's Peak, is 1630′. This is in the area south of Port Esperance and the dolerite is continuous from sea level. However, some faulting has occurred and it is estimated that the thickest sill of dolerite here is less than 1000′, but these are fed by broad dykes.

The general composition of the dolerite has been described by Edwards (1942) and the presence of olivine in the chilled margins has been recorded by Prider (1947). A porphyritic, olivine-bearing basalt (the chilled margin of the dolerite) has apparently been taken by Twelvetrees (1915) and Reid (1922) to be part of a Tertiary basalt flow.

However at Hope Island, no sign of any rock except massive dolerite weathered boulders of which sometimes have pitted surfaces could be found. In the other locality, Strathblane, a fine-grained rock, carrying dark coloured phenocrysts in a micro-crystalline ground-mass is often seen. Usually the phenocrysts have weathered out leaving an iron-stained pit in the rock surface. This rock was found *in situ* over the anthracitic coal at Adamson Run 6 No. 25294 distance 0·4″ bearing 144° and is the chilled base of the dolerite sill there.

Similar basalts are found at Adamson Run 5 No. 25273 distance 1·95″ bearing 176° where narrow dykes ranging from two feet to perhaps an inch in width are found in the margin of the dolerite and as a 3″ sill traversing the Grange Mudstone. These are fine grained basalts containing

glomero-porphyritic felspar and pyroxene in a glassy matrix showing incipient crystallization patterns. Some felspar laths can be distinguished in this groundmass. The basalt represents a quickly cooled phase of the dolerite and was probably intruded along cooling joints late in the magmatic cycle. Similar veins are found in nearly every outcrop of the dolerite.

A pegmatitic phase of the dolerite is also often seen. The pyroxene crystals in these segregations which, in this area, are never more than a square yard or so in extent may reach a length of ½". A good development of this phase can be seen near the bridge at Adamson Run 6/25289 distance 1·6" bearing 226°.

The main masses of dolerite are the normal, medium to coarse-grained, blue-grey, or greenish dolerite. Columnar jointing occurs in all the large masses but intense jointing near contacts causes either platy dolerite or irregular fragments showing confused jointing.

The only true dyke observed is that reaching the Esperance River near the coal bins at Folkestone. All the other visible outcrops are transgressive sills.

The contact effects are variable even in the same beds. Shales show baking often for a few feet; the quartz sandstones in some places show no sign of intrusion an inch away from the contact but in other places a hard siliceous hornfels several feet thick is formed. At the prospect pits mentioned above at Dover, the graphite present in the original sandstone persists in the hornfels.

The Ferntree Mudstone similarly behaves in two fashions. At the quarries at Folkestone and Raminea the mudstone is intensely baked yielding a blue-grey quartz hornfels. At Raminea the former sediment is hardly recognizable but the mud-balls are preserved as voids giving with quartz pebbles an indication as to the original boundary of the sediment. In contrast to this where the intrusion is dyke-like, on the opposite bank of the Esperance River at Adamson Run 5, 25270 distance 0·6" bearing 198°, the overlying sill has caused hardly any change in the sediment except a slight hardening immediately below the irregular contact.

TERTIARY SYSTEM

Syenite-Porphyry

Two dyke-like bodies of syenite porphyry are on the north-western shore of Brook's Bay and another on the boundary at the first point west of White Bluff. The rocks are similar in all respects. Both are slightly kaolinised, but not markedly so, on exposed surfaces.

The age of these rocks is not known exactly. At Cygnet similar rocks intrude dolerite and are therefore post lower Jurassic, depending on the age of the dolerite. At Brook's Bay they are intensely slickensided by movement upthrowing the west side of the quarry.

If the slickensides are not due to purely local causes, since the syenite is post-dolerite, it must have been caused by Tertiary faulting which from evidence in other regions is considered to have taken place in the Oligocene or early Miocene. This would mean that the syenite could have been intruded between the time of intrusion of the dolerite and the Oligocene or early Miocene. Both the intrusions here are into Ferntree Mudstones.

At Brook's Bay the inland extension of the dyke is concealed by soil and detritus from the Triassic beds. At White Bluff each end runs out into bays. The little island offshore here is in sediment, showing that the intrusion is in the form of a dyke.

The hand specimen shows vitreous phenocrysts (1·5 x ·5 cms.) of felspar showing multiple twinning and zoning. The grey groundmass includes crystals 3 m.m. long of a dark ferromagnesian mineral, smaller felspar laths and abundant pyrite. The thin sections show that the rock closely resembles the syenite-porphyry (banatite) described by Edwards (1945), from Cygnet.

PLEISTOCENE AND RECENT

Gravels associated with river terraces, for the lack of any evidence as to their age except that they overlie all the above rock types, are assumed to be the result of the increased power of transportation available during the Pleistocene glaciations. It is possible that some of them may be Tertiary in age but this cannot be proved.

The Strathblane Gravels cover the area shown in this locality on the map and are especially well developed on the hill top at Adamson Run 6 No. 25288 distance 4·1″ bearing 336°. Here in the old gravel pits, pebbles of chalcedony, chert, quartzite, schist, granite, mudstone, dolerite, fossil wood, and fragments of shells are cemented with a clayey matrix. These range from sand grade to boulders of sandstone two feet in diameter. This sandstone contains the pink quartz seen in the Triassic conglomerate on Raminea Plain showing that these beds were exposed at the time of formation of the gravel deposit.

A similar gravel but lacking the large sandstone boulders and pink quartz pebbles occurs along the Creekton Rivulet at the north-east corner of the Strathblane Plain. Rather more quartzite occurs here and the peculiar siliceous stone found in the quarry along the Hastings Cave Road frequently occurs. The higher parts of this creek run through deposits of quartz sand.

Along the Esperance River and Big Creek, the slip-off slopes and the extensive cutting-grass and ti-tree covered plain between them is covered with alluvium which is usually from 5-10 feet thick. The unsorted nature of this deposit suggests that it may be a till or a fluvo-glacial deposit very close to its source area.

The deposits usually begin with a layer two or three feet thick composed of boulders of dolerite, quartzite, sandstone, mudstone, and hornfels. Minor amounts of igneous and metamorphic rocks appear to be from redistributed Permian beds. All these larger fragments are held in a clay matrix where the deposit is deep. Above them lie finer beds consisting of a sandy clay.

The alluvium at the northern boundary is not so well sorted as at the junction of the two streams. Boulders of dolerite up to 2′ in diameter occur throughout and the interstitial matter is sand.

Stray water-worn pebbles of silicified wood, rounded quartz, and quartzite pebbles are commonly found well above the present creek beds.

These are often found on the dolerite which now caps the hill so that they are not derived from sediments in their present positions. They could have come from the sediments which originally overlaid the dolerite or been dropped during the early part of the present cycle of erosion.

Sand is being deposited at the present time during floods along the course of the Creekton Rivulet as it flows on to the Strathblane Plain, but elsewhere the streams are actively eroding their beds.

Between Raminea and the mouth of the Esperance River large islands and mud flats are being built up from mud and sand. The creeks entering Desolation Bay are filling this bay with similar material. Similar deposits of pebbles, sand, and mud block the mouths of most of the creeks flowing into the Huon.

Structural Geology

The area as a whole is a downthrown fault block. The date of the formation of this block can be said to be post-dolerite, but, so far, no further evidence has been found in the area to elucidate this matter. The fact that the block-faulting took place later than the dolerite intrusion is shown by the presence of dolerite on the summit of Adamson's Peak.

Dolerite outcrops along the Adamson track at the extreme west of the mapped area. This is replaced to the west along the track by a Permian bed in which one fossil *Stenopora* was present. This is succeeded by the higher Permian beds and then the Triassic. This is again faulted repeating the sequence but beginning higher in the Permian. Another such uplift occurs before the plateau is reached. Beyond the plateau there are further fault blocks before the dolerite which caps the mountain is reached. Therefore, in a horizontal distance of perhaps 1½ miles, there is a vertical uplift of at least 3000 feet.

When the downthrown block is examined, it can be seen that it consists of a number of basins of sediment separated by dolerite. These areas are roughly rectangular in shape, and were obviously formed by the tensional conditions that enabled the dolerite to rise through the crust.

However, superimposed on this Jurassic faulting is a later set of joints. The two sets and all the minor joints caused by the intrusion of the dolerite, especially close to the contacts, give a very broken nature to the rocks. As mentioned previously, in most of the sediments, the jointing has cut the rocks into blocks seldom more than a yard square. It is not unusual to find 4 or 5 sets of joints in the one spot.

Most of the joints are vertical, but in the quarry at Strathblane and also at Raminea, both close to the dolerite, joints with a dip of 70°-80° were measured. This type of joint may be caused by a magma, in this case the dolerite, at an intermediate depth giving insufficient support to the rocks above them.

In this case the forces are relieved by shear failure. Alternatively they would be conjugate shears close to a normal fault. The latter view is weakened by the proximity of the dolerite.

The dolerite itself shows columnar jointing in large outcrops, but the border zones are usually intensely jointed sometimes by sets of joints an inch or less apart and nearly parallel to the boundary, but in other places by numerous irregular cracks.

As well as these cooling joints, many large joints and shear zones can often be seen indicating the post-dolerite faulting. These are often accentuated by the drainage and are very noticeable south of Pt. Esperance. Here they cut the country up into a number of hills separated by dry valleys. A similar joint runs north-westerly from Tower Bay and one nearly parallel to this cuts through the dolerite from Roaring Beach to Glendevie.

An analysis of all the joints measured show a concentration of joints in 4 directions: 39°, 59°, 129° and 169°. The most pronounced joints are those bearing 129° and 169°. These concentrations of joints can be considered to be two sets of conjugate joints: the 39°-129° set and the 59°-169° set. This type of jointing is considered to have taken place under simple shear but the evidence from this area is too conflicting for any statement as to the nature of the forces or the direction of the major active forces to be given.

Because a fault at Police Point bearing 59° displaces the dolerite, it is considered that the 59°-169° set is associated with the Tertiary faulting and this is supported by the big linears cutting the dolerite south of Port Esperance. If this is so, it is thought that the 39°-129° set of joints are associated with the Jurassic faulting and the emplacement of the dolerite.

In general, however, this area is not strongly faulted. Only in a few places can a displacement of more than 200 feet have occurred. This type of faulting has been masked by the thick undifferentiated Triassic and Ferntree beds and by the dolerite. Even in the breaks caused by the dolerite, the throw need never be more than 200 feet. The local structure is most easily followed by tracing the dolerite boundaries.

Beginning in the south-west portion of the map along the Old Hastings Road, a chilled margin is found to lie transgressively over Knocklofty beds from which no dip could be obtained. This dolerite appears to be a sill.

Between this and the dolerite seen across the break filled with Knocklofty beds, a strong lineament runs across the whole area. This lineament, mapped as a fault, extends towards Lady Bay to the south-east. Towards the north-west a gap down which the upper part of the Esperance River flows is cut off finally by the Hartz Mountains. In the south no great displacement can be seen, but where this break crosses the Green Hill track, the dolerite-Felspathic Sandstone contact stands at 900 feet on the east, but on crossing the valley, the same contact is found at 1050 feet, i.e., an upthrow of 150 feet to the west.

The dolerite to the north of this gap extends as a continuous outcrop (see Dover sheet) to D'Entrecasteaux Channel. Between the junction of the Old Hastings Road and the Huon Highway and Strathblane, the dolerite has the form of a dyke with a slightly transgressive sill-like extension over the Permian at Strathblane. Faulting accompanied this intrusion because Permian beds to the north of the break are replaced to the south by beds which from the lack of any cliff-forming beds here must be high in the Knocklofty Formation. This would give a downthrow to the south of about 200 feet. The remainder of the southern boundary which where seen appears to be dyke-like, could not be traversed.

It is along this boundary that the long north-west to south-east lineation from Tower Bay passes. From the heights of the dolerite through which this break passes it seems that this downthrows to the south, but the throw would not be considerable.

On the north of this dolerite, the Raminea Plain is occupied by Triassic sediments which have a general southerly dip towards this dolerite. The dolerite boundary rises transgressively from a height of 150 feet over Knocklofty beds to 900 feet over the " Felspathic " Sandstone.

The cliff along the east side of Esperance River in this area is probably due in part to faulting but until the Knocklofty Formation is sub-divided and the position of the clay-pellet bed determined this cannot be proved.

The breaks in the dolerite and the steep dips (19°) in the beds near the Strathblane coal mines, added to the presence of quartz sandstone along the track that runs nearly parallel to the western border of the area, suggest that a major Tertiary fault runs down to the west of the dolerite sill crossed near the southern track junction. This could not be checked. It is also probable that strong faulting almost at right angles to this occurs here but no evidence for this could be found inside the area.

The dolerite, along the east boundary of Raminea Plain Triassic, shows, by its erosion pattern where streams cross the boundary, that it is a sill. However, a dyke occupying a fault may occupy the core of this outcrop where it crosses the Esperance River, because the Permian which underlies the discordant sill behind Raminea stands as high as the lowest Triassic west of Burn's Hill.

The scarp on the northern side of Burn's Hill appears to have been caused by the erosion of the Knocklofty beds underlying it. If it is faulted, no evidence for this was found except for a topographical break.

The Permian rocks which, south of the Esperance River, appear to be intruded along a dyke-like contact and cut at Folkestone by a definite dyke of dolerite, are, north of river, covered by the eastern sill-like extension of the Burn's Hill dolerite, which here transgresses from the Fern-tree beds over the Knocklofty Sandstones and Shales.

It is likely that a fault passes down the valley west of the Hopetoun Road and passes along the eastern side of the dolerite on the area boundary north of Burn's Hill. If this fault exists and it has not been possible to trace it on the ground, it must pass through the clay pit of the Granton Brick Pty. Ltd. and across the Esperance River near its mouth. In the clay pit there is evidence for a fault between the shore and the top quarry. There is a break here of about 50 feet upthrowing to the west. West of this line the Permian sediments dip at angles from 2°-5° to the west. As the dolerite is approached the dip tends to increase a little. The Permian to the east of this is either horizontal or dips at low angles to just west of north.

The dolerite between Francistown and Dover is a sill transgressing from the Permian on to the Knocklofty, and shows some very irregular boundaries. However there is a fault which cuts across the north-east corner of the Strathblane sheet. This upthrows the block of Triassic shales that occur in the Dover township area.

This patch of sediment whose boundaries are obscured in most places by alluvium appears to be a block which sank into the molten dolerite. The dolerite has intruded over it at all visible boundaries except the faulted boundary around the north-west and northern boundary. The Permian near the school stands higher than the Triassic-dolerite border east of Dover, showing that the intrusion of the dolerite was accompanied by a fault downthrowing the Triassic.

North of this patch of sediment lies another dyke-like intrusion of dolerite linking the dolerite hills on each side of the Huon Highway. The faulting accompanying this intrusion must upthrow the block around Stanmore by at least 150 feet because the Ferntree Mudstone outcrops in this area at between 150 and 200 feet above sea-level. At Dover, the base is at sea level. Looking south from Stanmore the dolerite appears as a sill dipping over the baked sandstone (now a quartzite) towards the south-west.

Along the shore east of Dover, the Ferntree Mudstone dips towards the dolerite which here overlies the Mudstone as a sill. This sill continues over the Permian-Triassic boundary and appears to continue as a sill overlying the Knocklofty beds until at Roaring Beach it becomes dyke-like and the sediments are cut off.

Just beyond the Permian boundary on the foreshore and in the marine cliff on the east shore of Port Esperance, a strike fault breaks the lower Knocklofty beds. The dip on the Dover side of the fault is 10° to the north-east, but to the east the dip at the fault is 18° in the direction of 79°. This dip gradually flattens out away from the fault so that the beds near the next dolerite boundary to the south-east are almost horizontal. This drag indicates that the fault is downthrown to the east, but as the same beds could not be found on either side of the fault, the throw is not known. However, from its stratigraphy it could not be more than 70-80 feet. This fault cannot be traced across country but since its outcrop bears approximately 169°, it is probable that it belongs to the Tertiary fault system.

The dolerite of Point Esperance for some distance occupies a very narrow strip of land along the shore and has a straight contact with the sandstone where visible, but the outcrop is usually concealed by sand.

Near the dyke of dolerite beneath Red Cliff Farm and sawmill, and along the coast to Roaring Beach, a number of fault blocks seemingly connected with the dolerite intrusion are indicated by a number of changes in dips. A small transgressive sill or feeder dyke for the dolerite 200 feet above outcrops at the end of the small sandy beach in this area.

The patch of sediment at Surveyor's Bay, is completely surrounded by dolerite which is fine grained at the contacts seen along the beach where the floor of the sediment is seen over the dolerite.

The patches of sediment near the centres of Run 3 Numbers 25157 and 25156 are actually continuous under a thin belt of dolerite which has so weathered away that in places only a few boulders in a red dolerite soil indicate its former extent. All the boundaries seen are igneous contacts but, in the places shown on the map, the straightness of the contact suggests faulting.

The belt of sandstone along the coast westerly from Surveyor's Bay is overlain by a slightly transgressive sill. Big shears lie parallel to the shore-line here suggesting that this is a fault coast. This patch of sediment is cut off by dolerite which appears to be underlying this patch of sediment and overlying the next patch to the north. These beds dip at from 5°-10° in a direction of 154°. The dolerite covers this bed at its north-westerly extensions.

The dolerite which cuts off this patch of sediment rises transgressively from the shore where it lies over the Basal Grit. At road level it lies over

a current-bedded quartz sandstone and above this it cuts across the Ferntree Mudstone until it meets the fault at Adamson Run 2, 2954 distance 3·5″ bearing 140½° from the photocentre. This block of sediment is on the upthrown side of the fault and dips south-westerly.

The fault here was the only one found that has actually displaced the dolerite but the sedimentary sequence is hard to follow because the outcrops are poor. However it seems that this is a normal fault upthrowing to the south and is Tertiary in age.

The downthrown block which contains Ferntree, Basal Grit, and Knocklofty beds all cut off inland by the continuation of the transgressive sill is also downthrown by Jurassic fault which passes through the gully at Adamson Run 2 Photocentre 2954 distance 1·9″ bearing 180°.

At this locality the dolerite rises (from the transgressive sill about 100 feet thick which is intruded into the Knocklofty sandstones) vertically up the fault plane as a dyke for a height of about 100 feet and then spreads out as a sill again to the west of the crest of the hill.

The fault has upthrown the northern side about 300 feet so that the Basal Grits now outcrops around the hill at about 450 feet and is succeeded by the Knocklofty Sandstone.

From this fault, the dolerite in a dyke-like body has separated the mainly Permian block from the Triassic beds to the west. The western boundary of this body takes an erratic path down to the Huon River just beyond the Police Point road junction. It just allows a very baked contact of Triassic sediment to reach the water's edge here and then spreads diagonally across the main road beyond where the Glendevie-Police Point road meets it. The upper limit and northern edge of this body cannot be traced but apparently it leaves a very narrow strip of sediment along the southern shore of Desolation Bay for the contact is seen about half a chain south of the mouth of the bay which is in Knocklofty Shales.

The Ferntree Mudstones here outcrop from the Basal Grits at Run 2, No. 2954 distance 4·6″ bearing 138° to the dolerite contact at Police Point. The dip of these beds is 5°-8° bearing 155°, but the faulting, together with the lack of a stratigraphic marker horizon, makes it impossible to calculate a thickness. The section up the hill to the Basal Grits from sea-level gives a total of 450 feet here at a maximum.

The next block of sediment dips at 12° bearing 220° from Desolation Bay to beyond the area along the coast and its south-western boundary lies over the transgressive sill behind Police Point and extends to beyond Glendevie.

Along this western boundary, the dolerite transgresses from the Knocklofty beds at about 100 feet above their base until it lies along the " Felspathic " Sandstone under the ridge behind the shelf here.

Although there are big lineaments cutting across this plateau, no definite proof of movement was found in this area. The syenite-porphyry dyke is elongated so that it has the same orientation as some of the joints in the sandstone. This together with the intense slickensides present in the syenite suggests that it intruded along the jointing and that later movement took place in the same line of weakness. The attitude of the slickensided surfaces suggests that the south-eastern side was downthrown but the movement was small as the Ferntree outcrops on both sides with no great change in lithology.

The stratigraphic succession in this area is as follows:—

	Feet
Dolerite	800-1000
"Felspathic" Sandstone	50-100
Knocklofty Sandstone and Shales	450-500
Basal Grits	20
Ferntree Mudstone	70

These heights were taken with an aneroid barometer under variable atmospheric conditions and are not entirely satisfactory but the order of magnitude is indicated by them.

It can be seen that this area is formed of a number of sedimentary blocks which have been floated up and tilted in the dolerite as it was emplaced so that the dolerite body at the base of one block of sediment is over the next block to the north. This means that each block is faulted off and the fault filled with dolerite. On the rising ground inland, the sill forming the ridge covers the inland edge of every block.

The Permian sediments rise to a height of perhaps 200 feet in the Brooks's Bay area, but, in the Stanmore area, their base stands at 400 to 500 feet. This means that a fault upthrowing to the southern side at least 200 feet must run between these two areas. This could, in a similar manner to the faults occupied by dolerite dykes postulated elsewhere, be the core of the sill here or perhaps the fault that passes near the centre of Adamson Run 3 No. 25154, causes this movement. This fault has not been found on the ground in this area where it would traverse the dolerite but it has been mapped by R. Ford in the neighbouring area to the west.

Summary of Structure

To summarize, this area is dominated structurally by the dolerite intrusions of the Jurassic and the associated faults. The area is intensely jointed but no big faults are known over most of the area. The later period of faulting has taken place breaking across the dolerite, but in contrast to the country west of this area where this faulting, which, based on information from outside this area, is Lower Tertiary in age, controls the structure, it is here very subdued and hardly detectable.

Geological History

The geological history of this area began in the Kungurian Epoch (Banks 1952) with richly fossiliferous deposits from a low glaciated terrain under conditions approximating to those of the Ross Sea today. Icebergs dropped large erratics on to the sea floor where a coarse poorly sorted sand was accumulating.

As the epoch passed, the increasing frigidity killed off all life in the sea but some plants still supplied fragmentary evidence of life. The deposits became coarser as the sea became shallower. The landscape in metamorphic and acid igneous rocks remained low but, as the ice erosion continued, a new predominantly quartzite level was reached at the end of the deposition of the Woodbridge Glacial Formation.

With the coming of a more temperate climate, the agents of transportation weakened and the Ferntree beds were laid down from the same low terrain. Marine life here failed to recover but the dark colour

of these rocks and the abundant "fucoids" show that plant life had recovered to some degree. This plant life reached a maximum during the deposition, probably during the Tartarian Epoch, of the Cygnet Coal Measures. The climate was probably temperate to frigid at this time.

A second major pulse of the distant Hunter-Bowen orogenic belt (the first probably occurred at the time of deposition of the Risdon Sandstone) apparently raised the area above sea level at the end of the Permian deposition since the Cygnet Coal Measures have been deeply eroded.

This break in deposition was followed by deposition under monsoonal conditions of the Basal Grits. The seasonal aridity of the early Triassic is shown by the colour of the beds and the presence of salifers. Apparently, deposition took place in a series of shallow fresh-water lakes which dried out periodically to swamps covered with vegetation, sand, and mud. During wet seasons, great streams cut across the dried areas and lakes forming the symmetrical current-bedding.

The deposition of the shales and sandstones indicate that water level fluctuated a good deal and that deposition was probably from low hills separating the lakes and coal swamps formed as the climate became warmer. At about the time of formation of the coal, the volcanic activity heralding the intrusion of the dolerite increased resulting in the formation of the tuffaceous Felspathic Sandstones.

This period of deposition was terminated by the Jurassic faulting and the widespread intrusion of sills and dykes of dolerite. Following this intrusion the sedimentary cover has been removed from the uplifted dolerite blocks leaving no trace and, sometime subsequent to this intrusion, the syenite-porphyry was intruded.

After this peneplanation, the Lower Tertiary faulting occurred cutting across all the sediments, the dolerite, and the syenite-porphyry. This faulting gave the region its present outline and its present topography has been carved from the fault blocks by erosion.

No age can yet be given to the various clay and gravel deposits but it is thought that they and the levels on which they have accumulated are the result of the Pleistocene glaciation.

Very little deposition, except near the mouth of the Esperance River, is taking place at the present time. A minor deposit of sand is being placed along the banks of the Creekton Rivulet but elsewhere the streams are rapidly cutting down their beds. Aided by the removal of the vegetation by bushfires, the sandy weathered surfaces of the Triassic sediments are being eroded very rapidly in some places. As a rule though, the vegetation grows rapidly enough to prevent the denudation of even the steepest slopes.

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Locality Index

Brook's Bay	43° 14′	147° 2′
Claremont	42° 46′	147° 16′
Dover	43° 19′	147° 1′
Glendevie	43° 14′	146° 59′
Police Point	43° 15′	147° 3′
Raminea	43° 20′	147°
Roaring Beach	43° 18′	147° 5′
Southport	43° 27′	147°

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A Census of the Orchids of Tasmania, 1953

By

Winifred M. Curtis

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During the fifty years since the publication of Rodway's Tasmanian Flora the number of species of orchids known from the State has increased from 79 to some 125. The following list has been prepared in order to facilitate reference to descriptions of species not included in Rodway's Flora and to show where changes in identification and in nomenclature have been made for species previously recorded. The new records are marked with an asterisk. As work continues, changes and additions to the list will be necessary and I should appreciate information from collectors that would enable the list to be kept up to date.

Dendrobium *striolatum* Reichb.f.
Sarchochilus *australis* (Lind.) Reichb.f., S. parviflorus Lindl.
Dipodium *punctatum* R.Br.
Gastrodia *sesamoides* R.Br.
Spiranthes *sinensis* (Pers.) Ames, S. australis Lindl.
Calochilus *campestris* R.Br.
* *robertsonii* Benth. (Black 1943; Rupp 1943)
* *paludosus* R.Br. (Black 1943; Rupp 1943)
* *imberbis* Rogers (Nicholls and Olsen 1941)
* *saprophyticus* Rogers (Rupp 1947, a)
Thelymitra *ixioides* Sw.
aristata Lindl.
cyanea Lindl.
venosa R.Br.
* *azurea* Rogers (Black 1943)
* *grandiflora* Fitz. (Black 1943)
nuda R.Br. (Rupp 1943; Rodway 1903, described under *T. longifolia*)
* *retecta* Rupp (Rupp 1944)
rubra Fitz. (Black 1943; Rodway 1903, described under *T. carnea*)
* *macmillanii* F. Muell (Rodway 1923; Black 1943; Rodway 1903, described under *T. carnea* var. *robusta*)
* *pauciflora* R.Br. (Black 1943; Rupp 1943)
antennifera Hook.f.
flexuosa Endl.
Diuris *palustris* Lindl.
maculata Sm.
* *flavopurpurea* Messmer (Rupp 1943)
pedunculata R.Br.
sulphurea R.Br.
longifolia R.Br.

Orthoceras *strictum* R.Br.
Cryptostylis *subulata* (Lab.) Reichb.f., C. longifolia R.Br.
Prasophyllum *australe* R.Br.
flavum R.Br.
elatum R.Br.
brevilabre Hook.f.
patens R.Br.
* *patens* R.Br. var. *robusta* Nicholls (Nicholls and Olsen 1941)
* *odoratum* Rogers (Black 1943; Rupp 1943)
* *odoratum* Rogers var. *album* Rogers (Black 1943)
* *alpinum* R.Br. (Rupp 1943)
* *frenchii* F.Muell (Rupp 1943)
* *rogersii* Rupp (Nicholls and Olsen 1941; Rupp 1943)
fuscum R.Br.
* *gracile* Rogers (Black 1943; Rupp 1943)
* *concinnum* Nicholls (Nicholls 1948)
* *suttonii* Rogers et Rees (Rupp 1943)
* *uroglossum* Rupp (Rupp 1947, b)
* *brainei* Rogers (Nicholls and Olsen 1941)
archerii Hook.f., P. intricatum C. Stuart
morrissii Nicholls (Nicholls 1931; Rodway 1903, described under *P. archeri* Hook.f.)
despectans Hook.f.
nigricans R.Br.
* *beaugleholei* Nicholls, P. nudum Hook.f., Fl. Tas. not Fl. Nov. Zel.
brachystachyum Lindl.
rufum R.Br.
* *buftonianum* J.H.Willis (Willis 1953)
Microtis *unifolia* (Forst.) Reichb.f., M. porrifolia Spreng.
parviflora R.Br. (Rodway 1903, described under *M. porrifolia* var. *parviflora*)
* *oblonga* Rogers (Black 1943; Rupp 1943)
* *atrata* Lindl. (Black 1943)
Corybas *unguiculatus* (R.Br.) Reichb.f., Corysanthes unguiculata R.Br.
* *fimbriatus* (R.Br.) Reichb.f. (Rodway 1903, described under *Corysanthes pruinosa*)
diemenicus (Lindl.) Rupp et Nicholls
aconitiflorus Salisb., Corysanthes bicalcarata R.Br.
* *dilatatus* Rupp et Nicholls (Black 1943)
Pterostylis *concinna* R.Br.
curta R.Br.
* *acuminata* R.Br. (Rupp 1943)
nutans R.Br.
* *pedoglossa* Fitz. (Rupp 1943)
nana R.Br.
pedunculata R.Br.
cucullata R.Br.
* *falcata* Rogers (Rupp 1943)
* *vereenae* Rogers (Black 1943)
furcata Lindl.

Pterostylis *foliata* Hook.f., P. gracilis Nicholls (Nicholls and Olsen 1941)
* *alpina* Rogers (Rupp 1943)
grandiflora R.Br. (Rupp 1943)
alata (Labill.) Reichb.f., P. praecox Lindl.
* *decurva* Rogers (Rodway 1903, described under *P. obtusa*)
* *toveyana* Ewart et Sharman (Nicholls and Olsen 1941)
parviflora R.Br.
aphylla Lindl.
* *squamata* R.Br. (Rupp 1943)
barbata Lindl.
mutica R.Br.
* *cycnocephala* Fitz. (Black 1943; Rupp 1943)
* *pusilla* Rogers (Black 1943; Rupp 1943; Rodway 1903, described under *P. rufa*)
longifolia R.Br.
vittata Lindl.
Caleana *major* R.Br.
minor R.Br.
Acianthus *caudatus* R.Br.
exsertus R.Br.
reniformis (R.Br.) Schltr., Cyrtostylis reniformis R.Br.
Townsonia *viridis* (Hook.f.) Schltr., Acianthus viridus Hook.f.
Eriochilus *cucullatus* (Lab.) Reichb.f., *E. autumnalis* R.Br.
Lyperanthus *nigricans* R.Br.
suaveolens R.Br., Caladenia suaveolens R.Br. (Reichb.f.)
Burnettia *cuneata* Lindl.
Caladenia *patersonii* R.Br.
* *echidnachila* Nicholls (Nicholls 1933)
* *caudata* Nicholls (Nicholls 1948)
clavigera Cunn. ex Lindl., C. cordiformis Rogers.
dilatata R.Br.
* *reticulata* Fitz. (Black 1943; Rupp 1943)
filamentosa R.Br.
latifolia R.Br.
carnea R.Br.
* *carnea* R.Br. var. *pygmaea* Rogers (Rupp 1943)
angustata Lindl.
* *gracilis* R.Br. (Rupp 1943; Rodway 1903, described under *C. testacea*)
* *alata* R.Br., C. lyallii Hook.f., C. alpina Rogers (Rupp 1943)
* *pallida* (Nicholls 1942)
congesta R.Br.
deformis R.Br.
menziesii R.Br.
* *praecox* Nicholls (Rupp 1943)
* *longii* Rogers (Rogers 1932)
* *atkinsonii* Rodw. (Rodway 1923)
Chiloglottis *reflexa* (Lab.) Druce, C. diphylla R.Br.
gunnii Lindl.
* *pescottiana* Rogers (Nicholls and Olsen 1941)
* *cornuta* Hook.f., C. muelleri Fitz. (Rogers 1918)
Glossodia *major* R.Br.

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Observations on Some Tasmanian Fishes: Part V

By

E. O. G. Scott

WITH 4 TEXT FIGURES

Summary

1. Some general observations are made on *Anguilla reinhardtii* Steindachner, 1867 (large individuals), *A. australis* Richardson, 1841 (abnormally colored specimen; elver), *Bovichtus variegatus* Richardson, 1846 (rock-pool sample), differential effects of rotenone on rock-pool fishes (under *Bovichtus*).

2. Little-known species described are *Muraenichthys breviceps* Günther, 1876, *Macruronus novæ-zelandiæ* (Hector, 1871), *Brachionichthys hirsutus* (Lacépède, 1804).

3. Records are given confirming the inclusion in the Tasmanian faunal list of *Leptoichthys fistularius* Kaup, 1853, *Leptonotus semistriatus* Kaup, 1856, *Syngnathus curtirostris* Castelnau, 1872, *Callionymus calauropomus* Richardson, 1844.

4. Keys to the Tasmanian species of the families Anguillidae, Echelidae, Macrouridae, Bovichtidae, Callionymidae, Brachionichthyidae are supplied.

Introduction

This paper, the precise scope of which is set out in the Summary, follows the general plan of previous communications under the same title (Scott, 1934, 1935, 1936, 1939). In Part IV keys to the Tasmanian or Tasmanian and ad-Tasmanian [' ad-Tasmanian ' = occurring in, or otherwise pertaining to, the vicinity of Tasmania: the convenience of this apparent neologism would seem to justify its adoption] members of the families represented were for the first time included. It has been found there is a strong and widespread desire, especially among extra-Australian workers, for these synopses; and they are accordingly supplied again here. Where it has seemed likely to be helpful, the simple alternatives offered by the definitive clauses of the key have been supplemented by data not confined to mutually exclusive attributes: this additional information [set out in square brackets] should either increase the reliability of the identification, or serve to point towards the presence of an unexpected or unknown species.

Differences among statisticians on the definition of variance and the method of calculation of standard deviation—*cf.*, *e.g.*, Student (1908), Huxley *et al.* (1927), Simpson and Roe (1929), Fisher (1932), Ezekiel (1947), Snedecor (1950)—lead to alternative procedures the results of which are not strictly comparable; and it appears to be necessary at present in reporting numerical data to specify the conventions followed.[1] In computing the standard deviation of samples, ordinary, or unadjusted, standard deviation, defined by $\sigma = \sqrt{\frac{\Sigma\ (x-\bar{x})}{N}}$, is here used when $N > 15$; and special, or adjusted, standard deviation, defined by $\sigma' = \sqrt{\frac{\Sigma\ (x-\bar{x})}{N-1}}$,

[1] The differences here referred to are questions of convention and mode of approach. A 'probably true value of the standard deviation' appearing in the ichthyological volume (Kyle, 1926: 176) in a well-known series of Biological Handbooks, however, exists only in the misapprehension of the writer.

is here used when $N \leq 15$. By what seems to be a logical extension of this usage, two corresponding coefficients of variation are recognized, viz, unadjusted, $V = \frac{\sigma \times 100}{\bar{x}}$, and adjusted, $V' = \frac{\sigma' \times 100}{\bar{x}}$. Standard (not probable) errors are recorded: for both adjusted and unadjusted statistics these are calculated from the conventional formulae, consistently using N. Except where otherwise expressly indicated, linear dimensions are given throughout in millimeters; the designation of the unit then being, for brevity and clarity, customarily omitted. Standard length and total length are denoted by *LS*, *LT*, respectively.

Family ANGUILLIDAE

Of six species of *Anguilla* Shaw, 1803 in the Check-List (McCulloch, 1929), Schmidt (1928) regarded only four as satisfactorily established as Australian: *A. bicolor* McClelland, 1844, *A. obscura* Günther, 1872, *A. australis* Richardson, 1841 (type locality Port Arthur), *A. reinhardtii* Steindachner, 1867; of which only the last two are Tasmanian, or ad-Tasmanian.

An index introduced by Schmidt, and here designated Schmidt's index, *S*, is of considerable value in the classification of the Anguillidae generally. It is defined thus: $S = \frac{a-d}{t} \times 100$, where a = length to vent, d = length to dorsal origin, t = total length.

Key to Anguillidae Recorded from Tasmania

A. *S* ranging from + 7 to + 14, mean about + 11. Color variable but usually dark, without copper tints. Characteristically spotted or marbled with darker (spots and marblings may be missing in very young and in old individuals). Head broad. Lips thick; maximum depth of upper lip about 5-6 in length of lip from tubular nostril. Teeth in upper jaw in two separate rows: mandibulary teeth divided by longitudinal toothless groove. Vomerine teeth in subtriangular, pennon-like patch, widest anteriorly; usually extending as far, or nearly as far, back as rows in upper jaw. Vertebrae 104-110, mode about 108 ..... *A. reinhardtii*

AA. *S* ranging from − 2 to + 4, mean about + 1. Color usually pale, or rather pale, greenish brown, with some copper tints. Unspotted. Head narrow. Lips thin; maximum depth of upper lip about 7-8 in length of lip from tubular nostril. Teeth in upper jaw in a continuous band, at least four teeth wide at broadest portion: no longitudinal toothless groove in mandible. Vomerine patch of teeth more or less oval or obovate; usually not extending nearly as far back as bands in upper jaw. Vertebrae 109-116, mode 112 or 113 ..... *A. australis*

Genus Anguilla Shaw, 1803

Anguilla reinhardtii Steindachner, 1867

Anguilla reinhardtii Steindachner, *Sitz. Akad. Wiss. Wien*, LV, 1, 1867: 15, figs. *a*, *b* & *d*. McCulloch, *Mem. Aust. Mus. Sydney*, V, 1, 1929: 64.
Anguilla reinhardti Schmidt, *Rec. Aust. Mus. Sydney*, XIV, 4, 1928: 182.
Anguilla marginipinnis Macleay (in part), *Proc. Linn. Soc. N.S.W.*, VIII, 1883: 210.

The inclusion in the local list of this species, which was not regarded as Tasmanian by Johnston (1891) or Schmidt (1928), has been discussed earlier (1934).

Large Individuals.—The linear dimensions of four very large specimens already recorded (1934, 1935) are exceeded by those of an example obtained in the North Esk, at Launceston, by Mr. J. Teague on 13th August, 1937. Even a technical paper may perhaps not unfittingly devote a sen-

tence to noting the dramatic circumstances of the capture of this fish. Mr. Teague observed it swimming close to the rowing sheds near the Tamar Street bridge; stabbed it in or near the heart with a pocket knife; jumped into the river fully clad, and brought the animal to shore. Some dimensions are set out in Table 1, accompanied by comparative data for the four large specimens previously noted. Schmidt, who regarded records of maximum size in *Anguilla* as of considerable interest, remarked he had not handled any specimen of this species exceeding 135 cm. in length and 7 kg. in weight, but cited references to examples weighing up to 30 lbs.: see also Stead (1908), Roughley (1916). Johnston (1883*a*) spoke of eels in the Ringarooma River and South Esk exceeding 30 lbs. in weight and 20 inches in girth, but he ascribed these to *Anguilla australis* Richardson, the only Tasmanian species he recognized: for record of a large short-finned eel, see Scott (1934: 39).

These fish of course come under notice, and become available for examination, primarily on account of their exceptional size; and hence constitute a biased sample. Even when the circumstances are borne in mind, however, the similarity of length and weight exhibited remains striking, and affords a strong suggestion the fish are drawn from a population characterized by a genuine biological homogeneity; presumably in respect of age. Simpson and Roe (1939) state that on comparing dozens of V's for linear dimensions of anatomical elements of mammals, they find the great majority lie between 4 and 10, with 5 or 6 as good average values: coefficients much lower than these are usually attributable to inadequacy of the sample, while much higher coefficients are usually indicative of some degree of heterogeneity (as of age or minor taxonomic status) of the material (Haldane (1952), who notes a modal V of 5 per cent. for linear measurements of mammalian teeth, points out this value is equivalent to an interquartile range of about 7 per cent. of the median.) The writer's experience points to the existence of a similar situation among fishes (with, *inter alia*, the qualification that here, as in other groups, among juvenile populations, in which more rapid growth tends to produce greater variability, coefficients of 10-12 are not unusual). It will be seen that the eight linear dimensions for which at least two measurements are available here show an adjusted coefficient of variation, V^1, of 2·4-9·4. Again, as Thompson (1942) has pointed out, weight varies as the product of three linear dimensions, and may accordingly be expected to exhibit a coefficient of variation that is (for small deviations—the biological situation) the sum of those of the three component variates (or, say, thrice the value of an average linear coefficient): likewise a girth coefficient tends to be twice a linear one. These expectations are well fulfilled by the present measurements, V^1 for weight being 3·5, V^1 for girth 2·1, times the crude mean for eight assorted linear dimensions (4·7). The appearance in Table 1 of several entries of $V^1 < 4$ exemplifies the tendency to low values characterizing numerically inadequate samples. At the same time, the entries for range/σ in general compare well with the values of the ratio range/standard deviation expected from random samples drawn from the normal population (the latter being: $N = 5$, mean 2·33, exceeded at $P = 0{\cdot}05$, $P = 0{\cdot}01$, 3·87, 4·59; $N = 2$, 1·13, 2·77, 3·64).

In all specimen S exceeds the mean (10·72) found by Schmidt for 84 specimens from New South Wales, and the present maximum closely approaches that among his material (13·2).

TABLE 1

Anguilla reinhardtii Steindachner: Dimensions of Five Large Tasmanian Specimens

Dimension: lengths and girths in mm.; weight in lbs.	Specimen (a) North Esk, near Launceston, 1937	(b) Hydro-electric fluming near Launceston, 1934	(c) Near Launceston, 1928	(d) Cataract Gorge mill-race, Launceston, 1908	(e) Longford (South Esk), 1908	Mean	Adjusted Coefficient of Variation, V^1	Range/σ^1
Total length	1671	1658	1531	1525	1635	1604·0	4·4	2·37
Length to base of caudal	1623	....	....	....	....	....	....	....
Length to origin of dorsal	540	488	517	476	501	504·4	5·0	2·55
Length to origin of anal	758	725	....	....	....	741·5	3·1	1·41
Length to origin of pectoral	225	208	....	....	....	216·5	5·6	1·08
Length of pectoral	119	....	....	....	....	....	....	....
Length to middle of vent	735	705	682	647	688	691·4	4·7	2·73
Length of head	212	....	....	....	....	....	....	....
Horizontal diameter of eye	14·8	17	....	....	....	15·9	9·4	1·47
Interorbital	58	60	....	....	....	59·0	2·4	1·41
Snout	40	42	....	....	....	41·0	3·4	1·41
Girth at vent	470	....	....	....	....	....	....	....
Girth, maximum	507	440	....	....	....	473·5	10·0	3·53
Weight	40	32	42	28	34	35·2	16·4	2·43
Schmidt's index, *S*	11·7	13·1	10·8	11·2	11·4	11·64	7·6	2·62

Anguilla australis Richardson, 1841

(FIGURE 1)

Anguilla australis Richardson, *Proc. Zool. Soc. Lond.*. IX. 1841: 22. *Id.* McCulloch, *Mem. Aust. Mus. Sydney*, V, 1, 1929: 63.
Anguilla australis occidentalis Schmidt, *Trans. N.Z. Inst.*, LVIII, 4, 1928: 388.

Variation in Color Pattern.—The short-finned eel is characteristically from pale greenish to olive brown, usually with some copper tints, above, silvery on sides, whitish below, and without any pronounced markings; notable divergences from this norm are very unusual. A remarkable variant, in which xanthochroism plays an important part, is afforded by a specimen secured in the South Esk, at Longford, on 30th November, 1931 by Mr. F. Wise. Principal dimensions: *LT* 329; length to origin of pectoral 41, of dorsal 128; length to vent 133; head 23, snout 7·5; horizontal diameter of eye 2·5; depth at origin of dorsal 17. $S = 1{\cdot}5$.

Lateral aspect: head almost wholly chrome yellow, with two superior rows of dark brown dots: ground-color of most of lower half of trunk chrome yellow, of most of upper half greyish; chief markings bold brown marblings, yellow-ivory spots, an elongated marbled whitish ventral preanal splash: greyish ground-color of tail marked with a good deal of brown, two rich ivory spots, and a fair amount of chrome yellow, the most brilliant of which occurs in sharply defined patches and spots: dorsal whitish, with thin basal yellow line, for about 90; thereafter brilliant chrome yellow, with one small brown blotch: anal whitish, marked posteriorly with four brownish blotches, the last very dark: details of pattern of lateral aspect shown diagrammatically in fig. 1. Elsewhere the fish manifests less abnormality: dorsal surface mainly greyish brown, becoming dark brown on nape; slightly in advance of dorsal origin an irregular greyish patch, about 14 x 10, in which occur some scattered dark brown spots; small dark spots mesially for about 20 cephalad from last-mentioned marking, and on occiput: ventral surface in general very pale yellow, becoming slightly pinkish on throat; only macroscopic markings are four irregular bluish brown blotches, 8-12 long, the first, beginning 50 behind tip of snout, situated mesially, second at right lateral profile, third and fourth at left profile, the last ending 90 behind snout.

Elver.—An elver in an early phase after the metamorphosis was observed in the Prosser River, at Oxford, about 150 yards from the harbor bar, on 10th September, 1952. At this point the complex of waves generated in the vicinity of the bar still persisted, meeting the sandy shore obliquely, with the production of a sinuous series of swift, swirling transgressions, smooth water being first encountered some 50 yards inland. The fish, which in gross appearance was virtually transparent, was swimming strongly upstream a few inches from the right bank; it was secured by a scoop of the hand. Examination after preservation in alcohol shows that though the general appearance in life approached transparency, a certain amount of pigment has been deposited. Chromatophores are in general subcircular on upper lateral and dorsal surfaces of trunk, where their area is subequal to area of their interspaces: on head, where they are more sparsely distributed, they exhibit a noticeable, but variable, tendency toward anteroposterior elongation.

Lower jaw projecting markedly beyond upper. Gape to below front of eye. Principal dimensions: *LT* 56·1, *LS* 55·2; length to origin of pectoral 6·4, of dorsal 20·6, of anal 21·6; length to vent 21·3; head 4·2, snout 1·4,

pectoral 1·1, horizontal diameter of eye 0·5; depth at origin of dorsal 1·1. Compared with the adult fish of *LT* 329 noted above the elver has lengths from tip of snout to origins of all fins relatively smaller, eye relatively larger (though not markedly so: 8·4, *cf.* 9·2, in head), relative depth much less (about-one-third). $S = + 1{\cdot}2$. This individual falls within the size-range (47-57) of a sample taken by Anderson and Whitley in 1926 in a creek crossing the beach at Long Bay near Sydney: none of these was a quite transparent elver, and Schmidt assigned them to Strubberg's (1913) Stage VI A ii.

Family ECHELIDAE

Only one Tasmanian genus, *Muræichthys* Bleeker, 1865. Check-List admits two Tasmanian species, *M. breviceps* Günther, 1876 (type locality Tasmania: Victoria, New South Wales), *M. tasmaniensis* McCulloch, 1911 (type locality Tasmania); a Tasmanian record of *M. australis* Macleay, 1881 (type locality New South Wales) by the writer (1936). For definition of Schmidt's index, *S*, used below, *cf.* Key to Anguillidae.

Key to Echelidae Recorded from Tasmania

A. Dorsal originating in advance of vent. Preanal length 1·6-2·0 in postanal length. Teeth in jaws biserial (sometimes triserial anteriorly?).
[Origin of dorsal nearer to tip of snout than to vent. $S = + 16\text{-}23$. Anal begins below about 80th-90th dorsal ray. Lateral line well arched over branchial sac. *LT* about 580 (larger type 20 inches).] .... *M. breviceps*

AA. Dorsal originating behind vent. Preanal length 1·3-1·4 in postanal length. Teeth in jaws uniserial.

B. Anal originating in advance of dorsal by < length of mouth. $S = - 2$ (type).
[Snout 5·3 in head. Interval between dorsal and anal origins about 1 in head. Lateral line somewhat arched over branchial sac. *LT* (type) 248.] .... *M. australis*

BB. Anal originating in advance of dorsal by > length of mouth. $S = - 7{\cdot}6$ (type).
[Snout 4·8 in head. Interval between dorsal and anal origins about 5-7 in head. Lateral line almost straight anteriorly (?). *LT* (type) 170.] .... *M. tasmaniensis*

Genus Muræichthys Bleeker, 1865

Muræichthys breviceps Günther, 1876

(FIGURE 2)

Muræichthys breviceps Günther, *Ann. Mag. Nat. Hist.* (4), XVII, 1876: 401. *Id.* McCulloch, *Mem. Aust. Mus. Sydney*, V, 1, 1929: 67.
? *Muræichthys macropterus* Klunzinger, *Arch. naturges.*, XXXVIII, 1, 1872: 43 (*nec.* Bleeker).
? *Muræichthys devisi* Fowler, *Proc. Acad. Nat. Sci. Philadelphia*, LIX, 111, 1907 (1908): 121, fig. 2.
? *Muræichthys ogilbi* Fowler, *Proc. Acad. Nat. Sci. Philadelphia*, LIX, 111, 1907 (1908): 423, fig. 3.

The original description, based on a 20-inch specimen from Tasmania sent to England by Morton Allport, and on a second smaller example of unknown origin, is brief and restricted in scope. The following observations on a specimen caught by Mr. Lyall in the Tamar River, at Blackwall, on 5th July, 1935, supplement in several directions the available information on this species.

Proportions and dimensions.—Length to origin of dorsal (94) 6·20, to anterior margin of vent (219·5) 2·66, to origin of anal (225) 2·59, in *LT* (583). Depth (and, in brackets, width) at eye 8·5 mm. (7·5 mm.), at middle of branchial sac 16·5 (12), at gill-opening 15 (12·5), at dorsal origin 14 (13), at vent 14 (13·5), the last, the maximum depth of trunk, 41·6 in *LT*. Mouth-cleft extends 13·5; maxilla 16, or to two eye-diameters beyond eye: a pronounced rictal fold.

Fins.—There appear to be no readily accessible records of radial formulae: a count here gives D.349, A.252. Anal begins below 85th dorsal ray. Fins, which were described by collector as 'lace-like,' were sunk, when specimen was received, in median grooves: erected as fully as practicable, they proved comparatively high, the anal slightly, but consistently, the taller. Height of anal (and, in brackets, of dorsal) at 25 anal rays behind vent 8 (7) ; at 150 mm., 50 mm. from tip of tail 7 (6·5), 3·5 (3).

Pore Systems.—Conspicuous systems of large pores on lateral and dorsal surfaces of head (fig. 2). Trunk series continuous anteriorly with the 6 on branchial sac, dipping rapidly (in about 5 pores) to, and thereafter following, about midline of flank; comprises 18 to dorsal origin + 35 to vent. On tail pores not countable with certainty posteriorly; total about 102.

Coloration.—Dorsal surface and upper half of lateral surface olive throughout. Ventral and lower lateral surfaces of tail whitish, speckled in parts with brownish; delimited fairly sharply from upper olive along pore-line. Lower lateral surface of trunk concolorous with corresponding region of tail; ventral surface silvery. Head conspicuously bicolor, with abrupt contrast, along a straight mediolateral line, between upper olive and lower light, mostly pale golden: the portion (about one-fourth) of the branchial sac lying in former region darker than surrounding area. Iris silvery, shot, especially above, with gold. Membrane of anal completely hyaline, without even microscopic punctulation: colorless to within about 100 of posterior extremity, behind which it assumes a greenish tinge, at first faint, becoming pronounced only in last 40-50. Membrane of dorsal mostly hyaline, with sparse brownish punctuations in basal one-sixth or one-fifth to within about 100 of end, punctulations then extending to basal one-third , or more; also a few scattered punctulations on outer part throughout length; but whole fin essentially clear macroscopically: colorless anteriorly; faint greenish amber developing in about last 100, becoming marked only in about last 50. Rays of both fins silver.

Remarks.—For the three proportions recorded by Günther (1876), the original material, *Endeavour* specimen, present example shows significant agreement, approximate values being: head 33 or 29, 37, 24 per cent of trunk, or 91, 93, 75 per cent of *LT;* dorsal-gill interval 50, 43, 47 per cent of dorsal-vent interval. Compared with our fish, the South Australian juvenile, 195 long, shows larger eye, longer snout, slightly larger mouth-cleft, lesser depth (all relative to head), decidedly smaller dorsal-vent interval in terms of length to dorsal origin; much lower fins.

Synonymy.—McCulloch expressed the opinion that specimens from Port Phillip and the Murray River identified as *M. macropterus* Bleeker, 1865 were probably *M. breviceps* (Günther distinguishes his species from Bleeker's only by its comparatively shorter head and longer snout). In his *Endeavour* synonymy he formally notes the possible identity of

M. breviceps with *M. macropterus* Klunzinger, 1872: the suggestion is, however, abandoned in the Check-List. I have not access to Klunzinger's diagnosis of his *M. macropterus*: in view of the implication of the specific name, however, it seems desirable to call attention to the quite respectable development of the fins in the present specimen. In *M. australis* dorsal and anal are ' scarcely visible ' (Macleay, 1881), ' very low, except near the end of the tail where they are a little broadened out ' (McCulloch, 1911); in *M. tasmaniensis* ' very low, almost rudimentary '. No mention is made of fins in Günther's account of *M. breviceps;* but those of the *Endeavour* juvenile are ' very low '. McCulloch's figure of the last-mentioned fish shows combined height of dorsal and anal shortly behind vent as about one-third of depth of body there, or subequal to eye; whereas in our example it slightly exceeds maximum depth of body, and is 1·3 combined eye and snout, or 6·3 eye.

Fowler's two species from Victoria described in 1908 do not seem to have been recognized since by Australian workers. There is, I think, little doubt that *M. devisi* is to be identified with *M. breviceps*. From the type of *M. devisi* the type of *M. ogilbyi* differs chiefly in dentition: the differences may be significant, but I am inclined to think the two specimens are probably conspecific. From Fowler's figures I estimate $S = ca$ 21 in both fish.

Family SYNGNATHIDAE

The Check-List credits Tasmania with 6 genera and 7 species: other contributions in present series (1934, 1935, 1939) add 3 genera and 6 species. A key covering these Tasmanian and some ad-Tasmanian species has already been given (1939); and the point of entry in this synopsis of *Syngnathus tuckeri* Scott, 1942 (haplotype of *Mitotichthys* Whitley, 1948) is indicated in its description. One species is here added to this local list and the inclusion in it of two other species is confirmed. (Recent fission of long-established genera (e.g., Whitley, 1948) would increase the generic tally given above.)

Genus **Leptoichthys** Kaup, 1853

Leptoichthys fistularius Kaup, 1853

Leptoichthys fistularius Kaup, *Arch. Naturges.*, XIX, 1, 1853: 233. *Id.* McCulloch, *Mem. Aust. Mus. Sydney*, V, 1, 1929: 92.
Leptoichthys castlenaui Macleay, *Proc. Linn. Soc. N.S.W.*, VI, 2, 1881: 295.

The recognition of this species as a Tasmanian form has hitherto rested on a single beach-dried example (1939). The collection of the Queen Victoria Museum, Launceston now contains a second specimen (Q.V.M. Reg. No. 1951·5·2), obtained at Woolnorth.

Fin Counts, Annuli.—D.36. P. *ca.* 20-25. A.? C.10. Annuli: total 23 + 20; subdorsal 2·9 + 5·3.

Principal Dimensions.—*LS* 405·8, *LT* 416·3 (caudal probably imperfect). Length to origin of pectoral 71·5, of dorsal 176·0; to termination of dorsal base 219·0; to vent 202·0. Head 63·3, snout 46·7, eye 6·2, interorbital 4·1. Depth (and, in brackets, width) at middle of snout 3·1 (1·2), front of eye 6·7 (4·0), opercular margin 9·0 (6·0), vent 7·5 (5·4), origin of caudal 3·0 (1·2) : maximum 10·6 (11·1) at 13th-14th annulus (ditto) about 115 behind tip of snout.

Remarks.—The conventionally-recorded proportions of this specimen fall in general within the normal range; though at 3·1 in trunk and 6·1 in *LS* head is, relatively, rather short. The number of annuli is exceptionally small, Waite and Hale's (1921) values (with the range found in their material followed, in brackets, by the wider range recorded by others) being 25-26 (28) + 20 (23-27). This fish exceeds the normal maximum length as given in the key (1939: 140); that value (360) being based on the largest example reported by Waite and Hale, the fact that the type itself measures 22 inches (Kaup, 1856) being unfortunately overlooked.

Genus **Leptonotus** Kaup, 1853

Leptonotus semistriatus Kaup, 1853

(FIGURE 3)

Leptonotus semistriatus Kaup, *Arch. Naturges.*, XIX 1, 1853: 233, *nom. nud. Id.* Kaup, *Cat. Lophobr. Fish Brit. Mus.*, 1856: 48. *Id.* McCulloch, *Mem. Aust. Mus. Sydney*, V, 1, 1929: 85
Syngnathus semifasciatus Günther, *Cat. Fish. Brit. Mus.*, VIII, 1870: 162; *emend. pro. Leptonotus semistriatus* Kaup. *Id.* Johnston, *Pap. Proc. Roy. Soc. Tasm.* 1882 (1883): 134.
Syngnathus verreauxianus Duméril, *Hist. Nat. Poiss.*, II, 1870: 573.

Though Johnston and Lord & Scott observe it is not uncommon (and Tasmania is type locality of Duméril's species), I have not hitherto seen any Tasmanian examples, and in providing a redescription and figure I was obliged earlier (1939) to employ a Victorian specimen. A pipefish from Low Head, Northern Tasmania, in the Aldie Museum, the private museum of Mr. Peter Mercer, Launceston, proves to be an adult male.

Fin Counts, Annuli.—D.38. P.14. A.?3. C.6. Annuli: total 20 + 46; subdorsal 4·2 + 5·1; brood 0 + 0·9 — 14·5.

Principal Dimensions.—*LS* 161·8, *LT* 164·5. Length to origin of pectoral 23·5, of dorsal 58·0; to termination of adpressed pectoral 26·5, of dorsal base 76·2; to vent 64·5. Head 22·0, snout 12·4, eye 2·9, interorbital 2·4. Depth (and, in brackets, width) at middle of snout 1·6 (1·4), front of eye 3·0 (3·2), opercular margin 4·8 (2·9), vent 4·7 (4·5), origin of caudal 0·9 (0·6): maximum 5·9 (4·8) at 10th (9th) annulus, about 43 (40) behind tip of snout.

Sexual Dimorphism.—The chief features distinguishing *Leptonotus* Kaup from *Syngnathus* Linné are the conspicuously elevated superior profile and the acute ventral surface in female in former. This sexual dimorphism is well illustrated in *L. semistriatus* by the following comparative proportions of the female from Victoria, *LT* 216, previously figured and the present male. Depth, at various points, in *LT*: at opercular margin 33·2, 34·3; at origin of dorsal 22·7, 32·9; at level of maximum depth 18·0, 27·9; at vent 32·2, 35·0, at middle of tail 72·0 74·8. Maximum width of body in maximum depth 2·4, 1·2 (in a female of the South Australian *L. costatus* Waite and Hale (1918), this ratio exceeds 3).

Brood Pouch.—I do not know of an illustration in local literature of the brood pouch: the ovisac (Mr. Mercer's specimen) is shown in fig. 3. It is constituted by two dark skinny flaps, 29 long, and contains 55-60 ova. Posteriorly the eggs are disposed in a single row below each flap (with occasional, usually less-developed supernumeraries), but in anterior one-third they tend, especially under right flap, to form an irregular double, or even at some points triple, series.

Genus Syngnathus Linné, 1758

Syngnathus curtirostris Castelnau, 1872

Syngnathus curtirostris Castelnau. *Proc. Zool. Soc. Vict.*, 1, 1872: 243. *Id.* McCulloch, *Mem. Aust. Mus. Sydney*, V, 1, 1929: 86.
Pugnaso curtirostris Whitley, *Rec. Aust. Mus. Sydney*. XXII, 1, 1948: 75.

The Check-List gives South Australia only: though included in Johnston's second local list (1891), the species is not accepted as Tasmanian by Lord (1923) or Lord and Scott (1924). A specimen collected, among *Hormosira* near low-tide level, at East Beach, Low Head, Northern Tasmania by Miss Ann Mather on 21st February, 1952 satisfactorily establishes this form as a member of our fauna.

Fin Counts, Annuli.—D.23. P.10. A.?3. C.6. Annuli: total 18 + 44; subdorsal 1·1 + 4·1.

Principal Dimensions.—*LS* 139·7, *LT* 142·8. Length to origin of pectoral 14·0, of dorsal 47·6; to termination of adpressed pectoral 17·0, of dorsal base 58·5; to vent 50·2. Head 13·0, snout 5·1, eye 2·4, interorbital 1·3. Depth (and, in brackets, width) at middle of snout 1·8 (1·4), front of eye 2·6 (2·0), opercular margin 4·7 (3·4), vent 5·0 (3·9), origin of caudal 0·9 (0·7): maximum 5·7 (4·9) at 7th (14th) annulus, about 27 (40) behind tip of snout.

Proportions.—Some important body-ratios, first in material examined by Waite and Hale (1921), secondly in type, thirdly in present individual: snout in head 2·5-2·7, twice, 2·5; eye in snout 1·8, once and a half, 2·1; eye in head 5·0, no data, 5·4; head in trunk 3·0-3·5, n.d., 2·9; head in *LT* 11·2, twelve, 13·8; base of dorsal in length to dorsal 4·8 (from fig.), n.d., 4·4.

Coloration.—It is proposed to make the coloration and color pattern of this fish the subject-matter of a separate paper.

Family MACROURIDAE

Six genera, with nine species, in Check-List: *Macruronus* Günther, 1873, *M. novæ-zelandiæ* (Hector, 1871); *Lepidorhynchus* Richardson, 1846, *L. denticulatus* Richardson, 1846 (type locality Port Arthur, Tasmania); *Cœlorhinchus* Giorna, 1809 (also spelt *Cœlorhynchus* and *Cælorhynchus* by authors), *C. australis* (Richardson, 1839), *C. mirus* McCulloch, 1926, *C. innotabilis* McCulloch, 1907; *Malacocephalus* Günther, 1862, *M. lævis* (Lowe, 1843); *Lionurus* Günther, 1887, *L. nigromaculatus* (McCulloch, 1907); *Nematonurus* Günther, 1887, *N. armatus* (Hector, 1875)—the first three Tasmanian, the fourth ad-Tasmanian (Bass Strait). The wide geographical distribution (associated with deep-water habit) of many macrourids suggests the local list may be extended as the result of future investigations: accordingly a key covering all the Australian species is provided.

Key to Macrouridae Recorded from Australia

A. Trunk > head. Second dorsal originating in advance of anal. Barbel absent or rudimentary.

[Head about 1⅔ in trunk. Mouth terminal, normal; to middle of eye, or beyond: jaws equal anteriorly, or lower projecting slightly. Eye ≤ snout. Anal originating below about 18th-20th ray of second

dorsal. Interdorsal 5-6 in first dorsal base. First long dorsal spine smooth. First dozen, or fewer, anal rays longer than rest. Teeth in upper jaw biserial, those of outer row larger: in mandible uniserial. Silvery plumbeous; trunk whitish below. *LT*: modal, about 530; to 935] .... *Macruronus novæ-zelandiæ*

AA. Head > trunk. Second dorsal originating behind anal. Submental barbel present.

B. Mouth lateral, high on side of face: top of upper lip about on, or above, level of inferior orbital border.

C. Trunk about 2 in head. Mouth terminal; snout anteriorly subvertical in profile, not projecting beyond upper lip. Anal originating behind first dorsal base. Premaxillary teeth noticeably heterodont.

[Jaws equal anteriorly. Snout 1½ in eye; orbital margin just cutting profile. suboperculum produced backwards as angular lobe. Second dorsal originating above about 20th dorsal ray. Interdorsal ≧ postorbital head. Anal high, subequal to snout: its rays at middle of tail several times dorsal rays there. No naked preanal groove. Head and body without markings, darker below; fins immaculate. *LT* about 530] .... *Lepidorhynchus denticulatus*

CC. Trunk about 7-10, or more, in head. Mouth subterminal; snout conical in profile, projecting beyond upper lip. Anal originating beneath first dorsal base. Premaxillary teeth homodont (or virtually so).

D. Eye not cutting profile, ≦ 1½ snout. Mouth to beyond middle of eye. Interdorsal subequal to combined eye and snout. Anterior anal rays short, several times in snout, subequal to first rays of second dorsal: > 20 anal rays anterior to second dorsal origin. Premaxillary teeth uniserial or biserial; mandibulary uniserial.

[No naked preanal fossa. Depth about 6-7 in *LT*. First dorsal spine smooth. No pronounced markings. *LT* about 400] .... *Malacocephalus lævis*

DD. Eye cutting profile, ≧ 2 snout. Mouth not to middle of eye. Interdorsal ≦ eye. Anterior anal rays long, about twice snout, many times first rays of second dorsal: < 16 anal rays anterior to second dorsal origin. Teeth in both jaws in villiform bands, the outer series somewhat enlarged.

[Tail abruptly narrower than trunk. Second dorsal spine serrate. Greyish; blackish on abdomen, posterior part of head; ventrals black; large black blotch on first dorsal. *LT* about 230] .... *Lionurus nigromaculatus*

BB. Mouth lateral, low on side of face; or inferior: top of upper lip below level of inferior orbital border.

E. Trunk about 1½-3 in head. Depth at first dorsal < length of head. A sloping ridge from near tip of snout to, or nearly to, preopercular border, dividing infraorbital region into subvertical upper section, and oblique, sometimes nearly horizontal, lower section: mouth wholly in latter. First dorsal spine smooth. Suboperculum produced into acute angle posteriorly. Teeth in villiform bands in both jaws: in mandible broadest in front, sometimes narrowing to one or two series laterally.

F. Depth small, about 10-12 in *LT*. Anal and second dorsal subequal in height. Orbit reaching profile.

[Eye about 1¾ interorbital. Second dorsal originating barely behind anal origin. Interdorsal ≧ first dorsal base. Light grey, with minute black spots; abdomen lips, ventrals black. *LT* about 240] *Cœlorhinchus innotabilis*

FF. Depth moderate, about 5-6 in *LT*. Anal distinctly higher than second dorsal. Orbit not (or barely) reaching profile.

G. Body deeper, about 5-7 in *LT*. Scales on upper surface of head spaced. Lower surface of head wholly or almost naked.

H. Interdorsal > eye, about twice first dorsal base. Eye > postorbital head. Anal rays subequal to snout. Median scales in advance of dorsal not forming crest. Body without dark cross-bars.
[Dorsal low; originating above about 8th-9th anal ray. Anterior dorsal spine minute. Depth ≤ head. Naked area round nostril. Lower surface of head naked, except for rugose scales between angle of mouth and angle of preoperculum. Head and body uniform grey: small black spot on lower pectoral rays. *LT* about 275] .... *Cœlorhinchus mirus*

HH. Interdorsal < eye, subequal to first dorsal base. Eye subequal to postorbital head. Anal rays ≤ ½ snout. Median scales in advance of dorsal forming crest. Body with about half a dozen dark cross-bars.
[Dorsal low; originating above about 4th-6th anal ray. Depth < head. Upper and lateral surfaces of head with small rough scales, lower naked. Four scales in transverse series between first dorsal spine and lateral line. Whitish: usually some anterior cross-bars not extending to ventral profile. *LT* about 250] *Cœlorhinchus fasciatus*

GG. Body shallower, about 6-7 in *LT*. Scales on upper surface of head closely set. Lower surface of head covered with asperities.
[Interdorsal subequal to first dorsal base. Snout > eye; very sharply pointed. Two or more oblique dark bars on body, sloping downwards and backwards. A dark band (best developed posteriorly) along whole base of anal. Scales well defined on some parts of head. L. lat. 96. L. tr. 5+ 18. (All these characters contrast sharply with those of the closely allied New Zealand *C. aspercephalus* Waite, 1911). *LT* about 530] .... *Cœlorhinchus australis*

EE. Trunk subequal to head. Depth at first dorsal ≥ length of head. No pronounced long oblique suborbital ridge, and no sharp division of side of head into subvertical and subhorizontal planes: mouth, though well below eye, and opening inferiorly, is low lateral, rather than inferior. First spine serrated. Suboperculum not produced into acute angle posteriorly. Teeth in both jaws uniserial.
[Snout obtusely conical. Interorbital flat, > eye. Eight scales in transverse series between first dorsal and lateral line. Interdorsal ≥ ½ head. Adpressed pectoral not nearly extending to anal origin. Lateral line not (or not clearly) developed immediately behind head. Uniform dusky; but some specimens much lighter, approaching white. *LT* about 330] .... *Nematonurus armatus*

Genus Macruronus Günther, 1873

Macruronus novæ-zelandiæ (Hector, 1871)

Coryphænoides novæ-Zelandiæ Hector, *Trans. N.Z. Inst.*, III, 1871: 136, pl. XVIII, fig. 1.
Macruronus novæ-zelandiæ Günther, *Rept. Voy. Challenger, Zool.* XXII, 1887: 157.
Macruronus novæ-zelandiæ Waite, *Rec. Cantab. Mus.*, I, 3, 1911: 180, pl. XXX, fig. 1. *Id.* McCulloch, *Rec. Aust. Mus. Sydney*, IX, 3, 1913: 358.
Macruronus novæ-zelandiæ McCulloch, *Mem. Aust. Mus. Sydney*, V, 1, 1929: 128.
Coryphænoids tasmaniæ Johnston, *Pap. Proc. Roy. Soc. Tasm.*, 1882 (1883): 143.

Johnston's species is undoubtedly conspecific with Hector's, with which, his account suggests, he was unacquainted. It occurs seasonally in schools on the West Coast (Johnston; Lord and Scott, *fide* Rodway), and at times enters the Derwent: it has been recorded from Northern Tasmania (McCulloch, 1913), and there is a specimen, *LT* 346, from the Tamar River, at Beauty Point, in the Queen Victoria Museum, Launceston (Reg. No. 1940·284).

In August, 1934, large numbers from Strahan appeared in some Launceston fishshops: the fish proved not at all popular, and local retailers found it expedient to instruct their suppliers to cease forwarding it. Observations on three individuals from this material *LT* (*a*) 527, (*b*) 530, (*c*) 545 usefully extend, or render more precise, previous accounts. Where three values are given below for one variate, entries relate to specimens in order just specified.

Barbel.—Hector (1871) says of the type, ' From under the jaw there is a larger bifid barbel, as in the cod ', and his illustration—which by reproduction (in outline) in Hutton and Hector (1872) and in Goode and Bean (1895) gained wide circulation—showed the appendage attached near base of chin at level of nostril. Günther, diagnosing (subgenus) *Macruronus* on *Challenger* material, notes ' barbel none '; remarking Hector's artist must have been under some misapprehension ' as, at any rate, the barbel could not be at the place where he has drawn it '. Johnston remarks ' barbel rudimentary ', and Waite (1911), supplying the first good figure, expressly records barbel absent. No indication of presence, or previous presence, of a barbel was found in any of our specimens.

General Dimensions and Proportions:—Proportions noted are extremes: for the more important ratios, however, individual proportions can be calculated, if required, from dimensions recorded (in brackets) at first mention of relevant variates. Head (87, 83, 89) 6·1-6·4 in *LT* (527, 530, 545), or 5·8-6·0 in length to base of ' caudal ' rays (503, 499, 515); snout (29, 21·5, 26) 3·0-3·9 in head; eye (28, 21, 24·5) 1·0-1·1 in snout; (soft) interorbital (17, 21, 22) 1·1-1·6 in eye, and, for (*b*) and (*c*), 1·2-1·5 bony interorbital. Length to origin of first dorsal (115, 96·5, 101) 4·4-5·5, of second dorsal (150, 139·5, 154) 3·5-3·8, of pectoral (93, 82, 87) 5·6-6·5, of ventral (114, 93, 105) 4·6-5·7, of anal (235, 231, 235) 2·2-2·3, in *LT*. Interdorsal (6, 6, 9) 2·9-4·8 in snout, or 11·7-19·7 in length to its midpoint. Trunk (143, 144, 141) 2·7-2·9 in tail: anus nearer to tip of snout than to tip of tail by 2·3-4·0 snout (*cf.* ' twice ' in *C. tasmaniæ*). Depth of head at level of orbit (43, 43, 45) 1·9-2·0 in length of head. Depth at vent (—, 62, 74) 1·2-1·3, maximum depth (—, 75, 86) 1·0-1·1, in head. Vent under 18th, 19th, 18th ray of second dorsal.

Head.—Maxilla reaches to below anterior 0·3, 0·6, 0·8 of orbit: lower jaw to below posterior half of eye, to 0·1, 0·2, of eye-diameter beyond eye. Width of hind end of maxilla 0·4, 0·7, 0·6 in eye. Jaws equal anteriorly, or lower slightly projecting. Mouth somewhat protractile. Upper margin of operculum smooth, or slightly striate and denticulate; lower margin

striated or ribbed, and from very slightly to moderately denticulate. Branchiostegals 7. About 22 gill-rakers on lower anterior arch, the front 1-1·5, the hindmost 10-11 long.

Teeth, Scales.—In lower jaw, on either side of symphysis, a row of about 5 minute teeth, together occupying about 3 mm.; internal to this set, a row of about 7 equally minute, occupying 3-4; behind second series about 10 more, with sagittate crowns, increasing in size backward, last about 3 long. In upper jaw, on either side, one enlarged tooth, 3 mm. or more long, near front, followed by about 14, subequal to each other, about half size of first; all sagittate: inside these a row of very numerous very small teeth. On vomer either a small patch, anteriorly of one row of very small teeth, widening behind on either side to two or three rows of rather larger teeth; or a narrow proconvex arc, several rows wide throughout. An elongated group, of variable form, of cardiform inferior pharyngeal teeth on each side. Two oval patches of superior pharyngeal teeth on each side, the hinder the more extensive and with somewhat larger teeth. Scales subcircular, cycloid, without spines. L. lat.: (*a*) imperfect anteriorly, 138 behind level of middle of pectoral; (*b*) damaged, estimated 190-200; (*c*) 166. Sc. tr. 8, 8, 9 between first dorsal and lateral line.

Fins.—Second dorsal and anal continuous round extremity of tail: about half a dozen rays of pseudo-caudal so formed shared in present fin-counts between anal and dorsal. D. I, 11; 105: I, 11; 104: II, 12, 104: in (*c*) only, a small initial spine, 2 long: large spine smooth. A. I, 91; I, 91; I, 93. V. 8 in one fin, 7 in other; 8; 8. P. (*a*) 17; (*b*) and (*c*) 18 in one fin, 17 in other. First dorsal begins less than eye-diameter behind pectoral origin: base 1·0-1·7 snout: 1st, 2nd, last rays 1·8-1·9, 1·7-1·8, 8·3-9·7 in head. Anal begins beneath 18th-22nd ray of second dorsal; base 1·76-1·80 in LT: first dozen rays rapidly, succeeding rays slowly, decreasing in height caudad; 1st, 2nd, 30th, 50th 2·3-2·4 ((*b*) and (*c*) only), 2·4-3·0, 5·9-7·9, 7·5-13·7 in head. Adpressed pectoral extends to level of interdorsal or 1st ray of second dorsal; base 4·3-4·5 in its longest (3rd-5th) ray, which is 1·6-1·7 in head. Adpressed ventral reaches level of 4th ray of second dorsal (specimen (*a*)); 1st ray, which is undivided, 1·6-1·7 in head, subequal to 2nd ray, 1·8-2·3 last ray.

Color.—Trunk silvery plumbeous laterally; similar, but with some greenish lights, above; whitish below. Head black above; concolorous laterally with flank; dusky silver below: mouth bluish black. Pupil blackish; iris mother of pearl, with some dark shading at margin, particularly below. Membranes of anal and both dorsals clear, greyish, lightly punctulated with brown, the free margins tending to blackish, especially posteriorly. Membrane of ventral hyaline, scarcely punctulated postaxially, but between first two or three rays so heavily pigmented as to appear almost black. Pectoral dusky.

Remarks.—Lord and Scott state this species is smaller than *Cœlorhinchus australis*, but its modal length is apparently several inches greater: one *Nora Niven* specimen measured 935 (Waite, 1911). The type (LT 21 inches; here taken as 533 mm.), the specimen described by Waite [in legend for pl. XXX, fig. 1 'two-thirds' should presumably read 'one-third'], and the present examples constitute a compact series with LT 513-545, $\bar{x}$ 529·6 ± 5·15, σ' 11·5 ± 3·64, V' 2·18 ± 0·69. Periodically approaches the shore (Günther): probably lives chiefly at 10-30 fms., which is decidedly shallow for a macrourid.

Family BOVICHTIDAE

In its wider connotation—as understood by, *e.g.*, Regan (1913), Waite (1921), Lord and Scott (1924), McCulloch (1927)—the Bovichtidae comprises: *Pseudaphritis* Castelnau, 1872, *Bovichtus* Cuvier and Valenciennes, 1831, *Cottoperca* Steindachner, 1876, of which the first two occur in Australia: in the Check-List, however, *Pseudaphritis* is referred to a separate family (Pseudaphritidae). The subjoined key covers the Australian bovichtids *s.l.*: *P. urvillii* (Cuvier and Valenciennes, 1831), *B. variegatus* Richardson, 1846, *B. angustifrons* Regan, 1913, all of which occur in Tasmania.

B. angustifrons (not included in local lists of Lord and Lord and Scott), which is based on two, probably halfgrown, specimens, one Tasmanian, one of unknown origin, does not differ trenchantly from *B. variegatus*. The most has been made in the key of differences noted in Regan's (1913) rather brief description or suggested by his illustration: it is not improbable, however, that some of the distinctions noted would fail to hold good if a large series, with a wide size-range, were available for comparison.

KEY TO BOVICHTIDAE RECORDED FROM TASMANIA

A. With scales. Body subcylindrical; head small, somewhat depressed. First dorsal originating behind pectoral base; quite separate from second dorsal (interdorsal > eye). Anal originating beneath interdorsal. Rays of all fins branched. Fluviatile .... *Pseudaphritis*

[D. VII-VIII, 19-22. A. 23-25. Head wholly covered with scales. L. lat. 60-65. Reddish sandy above, with dark blotches and marblings; white below] .... *P. urvillii*

AA. Without scales. Body high anteriorly, somewhat compressed; head large, high. First dorsal originating in advance of (or above) pectoral base; united (or virtually united) by membrane with second dorsal. Anal originating well behind origin of second dorsal. Anal, dorsal, lower pectoral rays unbranched. Marine .... *Bovichtus*

B. Interorbital wider (about 8-10 in head). Pectoral longer, relative to head (about 1·3-1·6, in small individuals modally, 1·4, in head). First dorsal apparently higher; 2nd spine ≧ 2·0 in distance from 1st spine to 1st dorsal ray. First dorsal with some dark marblings (characteristically two bars or two rows of spots); usually with conspicuous black spot on, and between, last two or three spines. About five dark bars on body, above lateral line; other (non coincident) bars below lateral line .... *B. variegatus*

BB. Interorbital narrower (about 12-13 in head). Pectoral shorter, relative to head (about 1·7 in head). First dorsal apparently lower; 2nd spine < 2·0 in distance from 1st spine to 1st dorsal ray. First dorsal without pronounced markings. Dark blotches or bars on body above lateral line only (Regan's figure) .... *B. angustifrons*

Genus **Bovichtus** Cuvier and Valenciennes, 1831

Bovichtus variegatus Richardson, 1846

Bovicthus [*sic*] *variegatus* Richardson, *Zool. Voy. Erebus and Terror*, Fish, 1846: 56, pl. XXXIV, figs. 1-4.
Bovichtus variegatus Waite, *Subantartic Islands of N.Z.*, II, 1909: 595. *Id.* McCulloch, *Mem. Aust. Mus. Sydney*, V, III, 1929: 336.
Bovichiths [*sic*] *rosco-pictus* Hutton, *Trans. N.Z. Inst.*, XXXVI, 1904: 148.

Johnston notes 'rare' (1883*a*), 'extremely rare' (1883*b*); but Lord and Scott (who inadvertently use the original *Bovichtus* on p. 12 and Agassiz's 1845 emendation *Bovichthys* on p. 78) state immature examples

are often taken in the Derwent Estuary. A specimen, *LS* 121, *LT* 143, from Penguin is in the Queen Victoria Museum, Launceston (Reg. No. 1942·173). Collections of rock-pool fishes made over many years on the North West Coast, in general without the aid of poisons, have not yielded one individual—possibly because of the difficulty with which this species is detected (Waite, 1909). However, by the use of derris 11 specimens were obtained at Penguin on 23rd January, 1952 from a single pool of maximum dimensions 8 feet 6 inches by 5 feet by 7 inches: bottom mainly stony; a few clumps of *Hormosira* sp. Specification of sample in respect of *LS*: range 38·0-56·8, $\bar{x}$ 46·31 ± 1·39, σ' 5·26 ± 1·12, V' 11·4 ± 2·4.

Differential Effects of Rotenone.—This operation, which in an hour yielded 35 fish representing four species, throws interesting light on some differential effects of rotenone. The species first affected was the present one: the fish soon began to move about slowly near middle of pool, and before long migrated to margin, where they were readily secured: all died with mouth wide open and upper jaw thrust forward. Next came 5 small individuals of the weed fish *Clinus perspicillatus* Cuvier and Valenciennes, 1836, LT 37·0, 40·1, 42·2, 46·9, 55·2, caught near water's edge. There followed 13 examples of the common blenny, *Pictiblennius tasmanianus* (Richardson, 1849), exhibiting the typical blustering and spluttering behaviour that has gained for them the local names of 'bullies': all died characteristically with clenched teeth. This series shows a slightly positive (g_1 = 0·013), non-significantly (t = 0·021) asymmetrical *LS* distribution, with range 38·9-72·2, $\bar{x}$ 56·36 ± 3·33, σ' 12·0 ± 2·36, V' 21·3 ± 4·4 — and perhaps comprises two year-classes: (*a*) 8 specimens, 38·9-59·6, $\bar{x}$ 48·18 ± 2·41, σ' 6·82 ± 1·71, V' 14·2 ± 3·5; (*b*) 5 specimens, 68·1-72·2, $\bar{x}$ 69·46 ± 0·78, σ' 1·74 ± 0·55, V' 2·51 ± 0·79. A single cling fish, *Volgiolus cardinalis* (Ramsay, 1882), LS 56, which, though venturing into open shallow water, did not show any indications of pronounced stupefaction, briefly preceded 5 large *Clinus perspicillatus*, *LT* 74·9, 78·0, 81·1, 84·1, 99·5, of which a couple were captured comatose under stones, while the others dashed along the surface, and then hurled themselves noisily on shore. Two shore eels, almost certainly *Alabes rufus* (Macleay, 1881), whose convulsive movements suggested they were suffering from the effects of the poison, were observed: these, which would have come last on the list, were not secured. There is thus disclosed a striking strictness of specific succession, and, in one instance, of inverse proportionality between body-size and speed of narcosis.

Variation.—Comparison of these 11 juveniles with the original description, based on two specimens, 8 inches and 5 inches long, from Port Jackson, with Waite's (1909) account of a rock-pool specimen, 55 long, and with Parrott's (1948) biometric analysis of a sample of 30 specimens from 8 localities in New Zealand and neozealanic islands shows good general agreement, with several noteworthy variations. Points worthy of notice are: (*a*) D. VIII, 19 in ten specimens, VIII, 18 in one (No. 7) [Waite's specimen VIII, 19; Parrott gives $\bar{x}$ 7·9, 19·2, with a maximum of 8, 21, while his mode (not specified) is probably 8, 19]: (*b*) A. 14 in ten specimens, 13 in one (No. 7) [Parrott records 14-18, $\bar{x}$ 15·4; so that the 18, *tout court*, of Lord and Scott (1924: 78), possibly based on Waite's single individual, does not represent anything like a modal or mean value]: (*c*) P. 10 + 5 in five, 9 + 5 in two, 8 + 5 in four, fish [present minimum total thus one below that of Parrott's material, which runs 14-15, $\bar{x}$ 14·5; and

present mode agreeing with Waite's single value]: (*d*) counting all rays, branched or simple, directed along general anteroposterior axis, I find C. 16 (one specimen), 17 (four), 18 (six), plus countable procurrent rays ¼-⅗: (*e*) Waite records ventral spine 1·4 in head (no data in Parrott), and longest pectoral ray equal to head; but present series, of comparable general size, yields 2·3-3·2, $\bar{x}$ 2·65 ± 0·092, and 1·3-1·6, $\bar{x}$ 1·44 ± 0·171, in head [from means in Parrott's Table No. 5 one computes pectoral 1·33 in head]: (*f*) posterior anal rays thickened and of same general character as lower pectoral rays, of which Waite found 4, here number 4 (one specimen), 3 (four), 2 (three), 1 (three).

Proportions in Present Series.—In view of its general homogeneity, the present sample provides excellent material for the study of individual variation (and in this respect complements Parrott's material, with an LS range of 39-196, and a wide north-south and east-west distribution). Examination of an extensive series of measurements and body-ratios, however, raises certain general issues regarding current ichthyological practice in specifying proportions too far-reaching for adequate presentation here: the tables and a discussion on them are accordingly reserved for a separate communication.

Family CALLIONYMIDAE

Three genera occur in Australia: *Dactylopus* Gill, 1860, *Synchiropus* Gill, 1860, *Callionymus* Linné, 1758; only the last Tasmanian or ad-Tasmanian.

Key to Callionymidae Recorded from Tasmania

The two species met with in Tasmania—*C. papilio* Günther, 1864, *C. calauropomus* Richardson, 1844—differ from all other Australian species in having preopercular spine devoid of basal antrorse barb, and provided with two terminal hooks (McCulloch, 1926). Both possess broad membrane uniting inner ventral ray with base of pectoral, and partly covering bases of lower pectoral rays: head and body depressed: dorsal rays branched.

A. Anal rays 6. Dorsals elevated; longest rays > ¼ LS. D. usually IV. 7. Ventral usually extending beyond origin of anal. Caudal normal ..... *C. papilio*

AA. Anal rays 7-8. Dorsals not elevated; longest rays < ¼ LS. D. usually IV, 8. Ventral not usually extending beyond origin of anal. Caudal sometimes (in old males?) with some rays greatly produced *C. calauropomus*

Genus Callionymus Linné, 1758

Callionymus calauropomus Richardson, 1844

Callionymus calauropomus Richardson, *Zool. Voy. Erebus and Terror*, Fish, 1844: 10, pl. VII, figs 4-5.
Id. McCulloch, *Mem. Aust. Mus. Sydney*, V, III, 1929: 338.
Callionymus achates De Vis, *Proc. Linn. Soc. N.S.W.*, VIII, 4, 1883: 620.

Lord and Scott list only *C. papilio*, treating *C. lateralis* Macleay, 1881, recorded as Tasmanian by Johnston (1891), as synonymic. (On the basis of original descriptions, this identification appears highly improbable; but McCulloch, who suggested it (1923), and maintained it in the Check-List,

examined the holotype of *C. lateralis*, and stated the D.8, A.8 of Macleay's account should be D.7, A.6). It is possible the inclusion of Tasmania among the Check-List localities for *C. calauropomus* is based on *Challenger* (Günther, 1880) or *Endeavour* (McCulloch, 1926) material from Bass Strait; and the recent capture of an example, *LS* 123, *LT* 165·5, in the Tamar River, at Launceston (Queen Victoria Museum Reg. No. 1952·5·3) appears worthy of record. The Museum has a second specimen without locality data, but probably of Tasmanian origin.

Both specimens are apparently females: as in the type, caudal is subequal to head, there being no marked extension of the 4th-7th caudal rays, in the form of filaments formed by terminal coalescence of the ray-branches, described by McCoy (1890) as characterizing old males; and the markings in the Tamar River fish (lost in other specimen) are consonant with McCoy's account of the female color pattern.

McCulloch and Waite (1918) draw attention to the fact that a South Australian specimen, *LS* 167, differs from the type in not having the teeth in the jaws reduced laterally to a single row; and McCoy's figures of a male, *LS, ca* 209, show the narrowest portion of the bands above and below as biserial. In the Tamar River specimen a number of the hinder teeth in both jaws are uniserial; while in the other example only the extreme tips of the bands of the upper jaw reduce to a single row.

Family BRACHIONICHTHYIDAE

The Check-List recognizes two Australian genera, each with two species: *Brachionichthys* Bleeker, 1885, (*a*) *B. hirsutus* (Lacépède, 1804), (*b*) *B. politus* (Richardson, 1849) ; *Sympterichthys* Gill, 1879, (*c*) *S. lævis* (Lacépède, 1804), (*d*) *S. verrucosus* McCulloch and Waite, 1918. Tasmania is type locality of (*a*), (*b*), (*c*) ; (*a*) recorded also from New South Wales, (*d*) from South Australia only.

The generic status of (*c*) and (*d*) is obscure. In the first place, *Sympterichthys* is separated from *Brachionichthys* primarily by a feature, the partial connexion by membrane of the three dorsal spines *inter se* and with the soft dorsal, regarding which different verdicts are derivable from two accounts—those of Lacépède and Cuvier—of the same specimen, the type of (*c*) [= *Chironectes unipennis* Cuvier, 1817]. Secondly, (*d*) is ascribed by its authors to *Sympterichthys* only by virtue of their so rediagnosing this genus as to exclude the palmary criterion on which it was based. It may be doubted whether among these fishes disjunction or partial connexion of some of the dorsal elements is in general of more than specific value (indeed, Johnston (1883*a*) was perhaps inclined to regard it as merely a matter of individual variation.). All species are provisionally referred below to *Brachionichthys*.

Key to Brachionichthyidae Recorded from Australia

A. Skin without spines.

B. Anal 9. Dorsal I, II, 17. First dorsal spine (which is free from second) without terminal fleshy appendage. First and second dorsals apparently joined. Skin perfectly smooth and soft. Anal base > first dorsal base; <2 in second dorsal base (measure-

ments direct, *i.e.*, not between normals to general anteroposterior axis). Dorsal and anal apparently not united by membrane to caudal peduncle. Outer margin of second dorsal with slight dip near middle, rounded off posteriorly. Red (in alcohol reddish brown), with lighter spots or marblings; two irregular pale blotches near base of second dorsal; some darker areas or markings over eye, between eye and pectoral, along base of dorsal ..... *B. politus*

BB. Anal 6. Dorsal I, II, 13-14. First dorsal spine (which is free from second) with terminal bunch of foliaceous appendages. First and second dorsals separate. Skin smooth or covered with low dermal tubercles. Anal base $\leq$ first dorsal base; $>$ 2 in second dorsal base (measurements as for B). Dorsal and anal united by membrane to caudal peduncle. Outer margin of second dorsal virtually straight to about antepenultimate ray; penultimate ray projecting. In alcohol brownish, with lighter and darker areas; two whitish blotches behind head; some indefinite brownish markings on cheek, back, abdomen; two dark spots on first dorsal; oblique dark marking covering posterior dorsal rays, caudal peduncle, almost all anal; pectoral and caudal blackish distally ..... *B. verrucosus*

AA. Skin with numerous small, or very small, spines.

C. Anal 9-10. Dorsal I, II, 19-20. First dorsal spine (which is free from second) with (simple) terminal fleshy appendage. First and second dorsals separate. Skin rough, with small spines. Outer margin of second dorsal with slight dip near middle, rising again to round off in last one-fourth; last ray about half first. In formalin, whitish or greyish brown; sides of head, trunk, tail with numerous conspicuous brownish or reddish spots, sometimes tending, especially on flanks, to form longitudinal rows; soft dorsal with many small red-brown spots, and anterodistal blackish blotch or blotches; anal with some dark markings and/or clouding ..... *B. hirsutus*

CC. Anal 9. Dorsal I, II, 16-17 (? III, 16-17). First dorsal spine (which is free from second, *fide* Lacépède's figure; or united with second, *fide* Cuvier) without terminal fleshy appendage. Skin nearly smooth, covered with minute spines. Outer margin of second dorsal convex; last ray about one-third of first. Preserved; reddish brown without conspicuous color markings ..... *B. lævis*

Genus **Brachionichthys** Bleeker, 1855

Brachionichthys hirsutus (Lacépède, 1804)

(FIGURE 4)

Lophius hirsutus Lacépède, *Ann. Mus. d'Hist. Nat.*, IV, 1804: 202 and 210, pl. LV, fig. 3.
Chironectes punctatus Cuvier, *Mem. Mus. d'Hist. Nat. Paris*, III, 1817: 431, pl. XVIII, figs. 2 and 5 (skeleton).
Brachionichthys hirsutus McCulloch, *Mem. Aust. Mus. Sydney*, V, 3, 1929: 409.

Early brief notices of this species do not appear to have been supplemented by an adequate description: Johnston's (1883*a*) account is short (though containing several useful observations: in radial formula 10-19 should read 16-19), while of notices of two New South Wales specimens Günther's (1887) is a record only, and Waite's (1898) chiefly a note on synonymy. Avery good colored figure (labelled Tortoiseshell Fish, *Cheironectes politus*), however, was early provided by Mrs. Meredith (1881). Observations here given are based on a slightly damaged specimen, *LS* 67·0, *LT* indeterminable (caudal imperfect), secured in the Derwent Estuary by Mr. B. Mollison.

Fin Counts.—D. I, II, 20. A. 10. V. I, 4. C. 10.

General Dimensions and Proportions.—Head, to middle of gill-opening (28·1) 2·4 in *LS*, rather less than twice direct distance between two gill-openings; length to middle of vent (33·3) 2·0 in *LS*, about three-fourths second dorsal base: head, trunk, tail thus 42, 8, 50 per cent., respectively, of *LS*. Eye (4·8) 5·9 in head, 1·2 in interorbital (5·7) : snout (3·5) 1·4 in eye. Trunk high, fairly wide anteriorly, compressed posteriorly; tail high, compressed. Maximum depth (19·5), occurring near origin of pseudobrachium, 3·4 in *LS*, subequal to length to origin of second dorsal: depth at gill-opening (18·6), at vent (13·9), at termination of soft dorsal (6·0), 1·0, 1·4, 1·3 in thickness at these points. Caudal peduncle (8·1) 3·3 in total tail without fin, subequal to combined eye and snout; its depth (5·8) 1·4 in its length.

Head.—Elevated, broad: height at front of eye (10·5), back of eye (16·3), front of pelvic insertion (18·2) 1·5, 1·4, 1·1 in thickness at these levels. Superior contour from lower lip to highest point (near middle of interdorsal) closely approaches quarter-circumference of circle of radius 16 (*i.e.*, three-fourths of postorbital head) with centre on horizontal level of angle of gape. Mouth moderately oblique, its cleft at about 30 degrees to virtually rectilinear pelvic-vent section of inferior profile. Lower jaw shorter than, largely enclosed within, upper: with mouth closed, cleft, viewed laterally, barely visible. A deep sulcus above upper jaw, continuous from side to side, running parallel with, and simulating, mouth-cleft, for which, when lips are closed, it might conceivably be mistaken (fig. 4*a*). Superior boundary of sulcus constituted by two long, slightly tumid lateral folds and a median eminence that their anterior extremities briefly overlap: from middle, most advanced region of this tumescence arises first dorsal spine (fig. 4*b*). Maxilla to below 0·5 eye. A small free interramal fold; its median extension caudad less than half length of gape; its posterior portion on either side extending up over maxilla, the end of which it encloses, and being apparently continuous with lateral fold above sulcus. Eye rather small, subcircular; its diameter subequal to its distance from base of first spine; not cutting dorsal profile (though supraorbital ridge in part constitutes profile). Interorbital wholly occupied for about one-third of its width by first dorsal. Interdorsal with median groove. A shallow infraorbital depression; cheeks tumid; chin and throat flattened. Nostrils small, simple, with slightly raised rims, opening at ends of short barrow-like eminence: the anterior on a level with hind border of base of detached dorsal spine, from which it is separated by rather more than spine's basal diameter; the posterior above the anterior by one-third of its distance from its fellow.

Teeth.—In upper jaw small, subcylindrical, slightly recurved, depressible, forming on either side a band three or four rows in width anteriorly, narrowing to one or two rows posteriorly. In either ramus of lower jaw a similar, but rather narrower, band of teeth resembling, but rather larger than, those of upper jaw, and showing some tendency to increase in size from in front backwards. No other teeth recognized. Most of palate, which is spanned anteriorly by a fairly wide frenum, carries papillae somewhat similar to, but larger than, the teeth. Tongue large, adnate right to its anterior extremity, the face of which is subvertical.

Mucigerous System.—A series of paired subconical tubercles extends from mandibular symphysis towards each pseudobrachium; several pairs

of small pores occur above, and some pores below, eye: but full extent of system cannot be made out (partly, no doubt, because of confusion—not infrequently encountered in angler fishes—introduced by presence of other dermal structures; probably partly also as result of preservation).

Gill-opening.—Small (in specimen as preserved about 1·5 in greatest diameter), somewhat elongated anteroposteriorly; closable, wholly or partly, by valvule at anterior margin; about half eye behind, about one-fourth eye above level of, upper angle of axilla: situated in backwardly sloping posterior face of a longitudinal elevation extending forward for a distance exceeding interpelvic interval, rapidly narrowing cephalad from a narrow, semicylindrical ridge, about half eye in dorsoventral extent, to an almost flush indication of a tube less than 1 mm. in diameter. Length to middle of aperture (28·1) subequal to distance from level of termination of soft dorsal to ridge delimiting anal region anteriorly, or 1·9 direct transverse distance between two gill-openings.

Fins.—First dorsal spine a simple, smooth, tapering, translucent, flexible rod, surmounted by a simple, fleshy, lanceolate illicium scarcely distinguishable, save by its rather greater flexibility, from its support; base bulbous, movably inserted into eminence forming median superior boundary of supralabial sulcus, length to base (0·5) thus being only anteroposterior extension of upper lip; illicium (2·1) 5·2 in total length of organ (10·9), the latter 2·6 in head, equal to distance from base of spine to posterior rim of bony eyesocket; not connected by membrane with, and moving quite independently of, second spine; as preserved, lying laxly against, and following curve of, snout and early forehead. Second spine originating behind first by more than basal diameter of latter; its (possibly incomplete) length (11·1) 2·5 in head, or about half direct distance from its base to origin of soft dorsal; wholly enclosed in skin; anterior face, for at least four-fifths of length, thickly set with spinules, a few of which extend on to immediately adjacent fin-membrane. Third spine (imperfect; present length 7) originating above anterior one-third of eye. Second and third spines together forming cristiform fin; membrane very thick and fleshy, especially basally: length to origin (1·6) 5·3 in length to termination (8·5); base equal to width of mouth. Interdorsal (10·0) subequal to longest pectoral ray. Soft dorsal originating slightly behind anterior insertion of pseudobrachium; length to its origin (18·5) 3·6 in LS, 2·2 in base of fin (40·4), the latter subequal to combined trunk and tail; 5th (in specimen the first perfect) ray (15·3) 1·8 in head, subequal to 10th ray, 1·5 17th: only a few rays are perfect, making contour of fin indeterminable; base only of last ray connected by membrane to caudal peduncle (but a damaged condition possible). Rays glassy, strongly septate: most, perhaps all, divided basally by deep median groove, pressure (*e.g.*, by tip of stylus) on which causes ray to split in longitudinal side-by-side halves, which (at any rate in anterior part of fin) are separately rooted and independently movable. Anal originating below 11th dorsal ray; length to its origin (38·0) 1·8 in *LS*, 1·8 base of fin (20·6), which latter is slightly more than half second dorsal base; terminating almost vertically below (0·3 mm. in advance of) dorsal termination; first ray (6·0) 4·7 in head, 1·4 in second ray; posterior rays distally imperfect, and fin contour uncertain, the indications suggesting height increases somewhat for first two or three rays, thereafter descending, if at all, but slightly, with any possible rounding-off restricted to last ray or two; base only of last ray

attached by membrane to caudal peduncle. Caudal imperfect, only proximal one-third present: all rays actually divided in plane along which dorsal rays split when pressed upon basally, namely, the sagittal; division complete, the two stiff hyaline rods inserted by separate roots, the distance between which, for any pair, exceeds basal diameter of a rod, so that, in present condition, fin presents two distinct apposed fans, whose truncated bases are set parallel, about 0·3 apart.

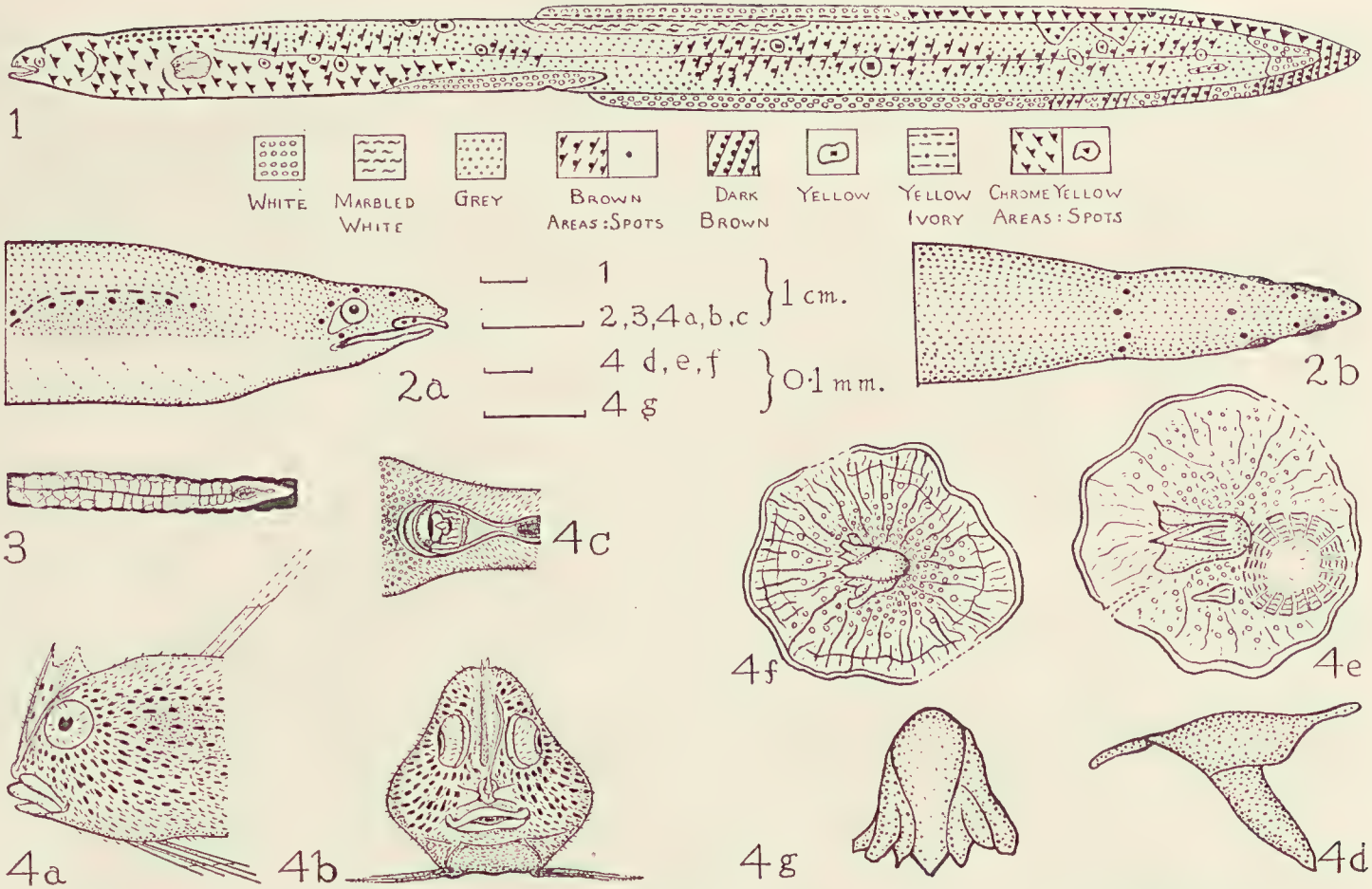
Ventrals originating just anterior to level of middle of interdorsal, or behind eye by about eye-diameter; length to origin (12·5) 2·2 in head, or about thrice anteroposterior extension of base of fin (4·0); longest (3rd) ray (11·3) 2·5 in head, 1·7 spine; laid back, extending almost to level of gill-opening; spine weak; rays externally simple, unbranched, but the glassy axis, when divested of membrane, readily splitting longitudinally in two. Interpelvic (8·8) exceeding width of mouth. The following account of the pectoral assumes fin to be adpressed to flank, with whole pseudobrachium subhorizontal, and rays directed upwards and somewhat backwards towards base of soft dorsal. Pseudobrachium well developed, with a bound anterior section, appearing as an obliquely longitudinal ridge below integument, and a free posterior section, from whose rounded extremity (chord of terminal arc inclined upwards and forwards at 45 degrees, or more, to horizontal line of belly) arise the simple rays, set in thick membrane; free section with superior border upwardly concave, inferior border nearly linear, oblique, the vertical height of lateral surface of arm at level of insertion of anterior rays (5·4) being 1·2 that at level of axilla; length to anterior insertion, beneath integument, (17·9) 1·5 in length to axilla (26·4), 1·9 in length to free distal border or ray-bearing 'wrist' (33·8), enclosed portion thus being 1·1 free; longest (4th) ray (9·4) 3·0 in head, tips of rays extending briefly beyond membrane. With pseudobrachium adpressed and held sufficiently obliquely just to cut inferior profile of fish (which it does at about vent), posterior border of fin, in unexpanded state, forms rather more than right angle with inferior border of pseudobrachium and points towards middle of soft dorsal base. Pectoral rays fissionable sagittally; less readily so than ventral rays.

Anal Region.—A lyrate region wholly free of spinules embraces, and extends behind, anus (fig. 4*c*); length (11·5) rather more than twice its width. Comprises, in succession caudad: two approximated proconvex ridges, separated by shallow groove; thick, fleshy anal flap, whose posterior border constitutes anterior border of vent; transverse aperture of vent; slightly tumid hinder lip of anus, middle one-third of lip being overlaid by small, wide-based subconical genital papilla; large, lightly longitudinally plicate depression, bounded laterally by subparallel ridges; less-depressed region, somewhat elevated mesially by continuations of same ridges (which thereafter extend caudad along base of anal fin).

Spinules and Scales.—Except for lyrate anal region, a small inferior portion of free section of pseudobrachium, lips and supralabial folds (including medial tumescence), central area of eye, bottom of interdorsal groove, fins in general (but see account of second dorsal spine), all external surfaces thickly beset with glassy spinules; which, however, exhibit some diversity of shape, size, frequency, inclination, relation to substratum. On midflank a typical spinule (fig. 4*d*) is subconical, slightly recurved, backwardly pointing, its main axis at about 60 degrees to body surface, set in a mammilliform eminence arising from near centre of subcircular

cycloid scale; lamina and a variable fraction of central boss of scale wholly buried in integument, through which, however, general shape of scale can usually be determined with lens; in example figured length of free spine (278 μ) is 2·9 its basal width (97μ) : in this region scales not contiguous, naked area about twice scaled area. On side of tail spinules similar, rather smaller; scales more closely set, less apparent. In a region roughly delimited in front and below by line from termination of first dorsal to near gill-opening and behind by vertical line from near gill-opening to base of second dorsal scales are somewhat more obvious, especially near superior profile at interdorsal, where they are contiguous, or virtually so: a scale from this region (fig. 4*e*) is 600μ by 555 μ; spinule complex, slant height 307 μ; secondary simple spinule, slant height 107 μ; ridge-system 253μ by 254 μ: a second scale from nearby (fig. 4*f*), 526μ by 502 μ, lacks ridge-complex; spinule (fig. 4*g*) massive and complex, slant height 156 μ, extreme width at tip 166 μ. On being drawn from head caudad along lateral surface of fish, finger-tip registers marked asperity, diminishing slightly on and near caudal peduncle. Much more difficult to run finger along skin in opposite direction; if any marked pressure is applied, impracticable to do so. On chin, throat, belly spinules set in circular concavities (particularly well-defined from level of ventrals caudad) and readily depressible: hence, with finger drawn caudad, surface feels almost smooth, while movement in opposite direction encounters resistance of the same order as that associated with caudad stroking on trunk.

Coloration.—Lateral surfaces in general a tolerably uniform, somewhat pinkish grey: ill-defined lighter areas behind and above eye; below front of eye; in advance of, and slightly above, pectoral insertion; inferolateral region of head; hinder portion of external surface of pseudobrachium; small patch on axilla. A broad dark stripe, most intense posteriorly, running forward and somewhat downward from below base of soft dorsal, a little behind level of gill-opening, towards eye, of which it stops short by more than eye-diameter; a short broad, oblique dark bar extending downwards and forwards from superior profile at termination of second dorsal to midlateral line, or beyond. On lateral surface about sixteen rows of red-brown markings, ranging from subcircular spots to anteroposteriorly elongated subrectangular blotches, radiating from eye: of these about half a dozen markedly oblique, terminating at, or a little above, inferior profile in advance of insertion of pseudobrachium, the first two of this series comprising each only three or four spots; three running down with moderate obliquity on to, and continuing nearly horizontally along, anterior half or more, of pseudobrachium; the rest running back, more or less parallel to body profiles, to beginning of caudal peduncle, and there ceasing abruptly. Behind vent a narrow inferolateral strip without markings. Anteriorly, several of the upper rows of spots contiuue in advance of eye on to dorsal surface, flanking base of spinous dorsal; posteriorly, uppermost row meets superior profile behind origin of second dorsal, so that interdorsal region is without spots not only on upper surface, but also along a strip of superlateral surface, of fish. Lower surfaces all immaculate; in head and trunk whitish; in tail concolorous with lateral surface. Lower lip whitish; upper lip and supralabial folds pale yellowish, nearly concolorous with inside of mouth. Pupil white; iris bluish. Thick membrane of first dorsal yellowish; with about half a dozen brownish spots, forming apparent continuation of series on forehead. Second



FIGS. 1-4.—1, *Anguilla australis* Richardson, 1841; abnormally colored specimen. 2, *Muræichthys breviceps*, Günther, 1876: head, showing pores; *a*, lateral aspect; *b*, dorsal aspect. 3, *Leptonotus semistriatus* Kaup, 1856: ovisac. 4, *Brachionichthys hirsutus* (Lacépède, 1804): *a*, head, lateral aspect; *b*, head, frontal aspect; *c*, anal region; *d*, scale from midflank; *e*, *f* scales from shoulder region; *g*, detail of complex spine of *f*.

dorsal apparently whitish, with some obscurely preserved darker spots; posterior three or four rays dark, almost black, the marking continuous with oblique bar on trunk. Anal pale yellowish. Ventral whitish. Membrane and rays of pectoral pale, faintly tinged with greenish yellow. Rays of caudal hyaline. (Life colors of fins as shown in Mrs. Meredith's plate suggest her vernacular name, Tortoiseshell Fish, is an appropriate one.)

Remarks.—The presence in this fish of distinct, readily recognizable scales is of interest. No mention is made of scales in any description of this, or of an allied, species that has come under my notice; and the old family Pediculati, *sensu lato*, of which the present-day Brachionichthyidae represents one section, was diagnosed as without scales on head and anterior part of body. The curious proneness to sagittal division of the fin rays of the vertical fins might, in itself, plausibly be interpreted as a retention of an early phase in the usual process of formation of these fins by the apposition (and, in most fishes—save as an abnormality—the subsequent complete fusion) of two lateral moities: but the same phenomenon occurs also in the other fins, each of which might be expected to arise from a single ' muscle bud '. It is possible, however, that an indication of the double origin of the vertical fins really, does exist in the shape of the two-rooted insertion of their rays; and that the tendency of fins-rays in general to split longitudinally is idiosyncratic.

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Some New Aspects of Tasman's Visit to the East Coast of Tasmania in 1642

By

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Introduction

The celebration, in 1942, of the tercentenary of the discovery of Tasmania prompted the late Archibald Lawrence Meston to find out whether more could be learnt about the events of those few days in December 1642 when Tasman's ships were anchored off the east coast of Tasmania. The two main questions at issue, many times disputed, are the sites of Tasman's first watering place and where the master-carpenter raised the Dutch flag of annexation. These two spots have been variously located, but it has always been held that Tasman's charts were quite inaccurate and that their 17th century topographical symbols were mere convention. Meston, however, took the opposite view, on the ground that no man in Tasman's situation could afford to be inaccurate, and he was prepared to assume that, on the visual data apparent to Tasman from his position and approach, he meant exactly what he set down in his journal.

Mr. Meston's findings were made known to the Society in a lecture which he gave on March 23, 1943: new evidence fixed Boomer Creek as the site of the watering place and the northern end of North Bay as the spot where the Dutch flag was raised. These conclusions were reached as a result of a thorough study of published material and examination of the locality itself. The latter involved several visits to Blackmans Bay and Forestier Peninsula. On one of these visits, in January 1943, he was accompanied by L. R. Jensen, Rosamond McCulloch and Janet Somerville, and for a week they walked over the coast-line from Cape Bernier to Wilmot Harbour and the whole shore of Blackmans Bay, as well as many places inland, examining topography and vegetation in relation to the record in log and charts.

In the manuscript of Mr. Meston's lecture to the Society he refers to a paper which he had prepared for publication. However, that paper was never completed, duties more pressing than the writing of history taking all his time. Even Mr. Meston himself realised that it might be a long time until his paper could be completed and so it was decided that the botanical evidence for the location of the watering place should be published separately: this was done by Curtis and Somerville (1948).

On Mr. Meston's death the Tasman material was found to include the draft of his lecture to the Society in 1943 and various jottings on additional data. From these sources and from recollections of the lecture delivered and of personal discussions with him the present paper has been extracted. It is largely in Mr. Meston's own words, only those parts being amplified which would otherwise not be clear.

Editors.

Arrival

On December 11, 1642[1] Tasman's two ships, the yacht *Heemskercq* and the flute *Zeehaen*, drew towards the land with an easterly breeze and "about one hour after sunset . . . dropped anchor in a good harbour, in 22 fathom, white and grey fine sand, a naturally drying bottom[2]". Sunset on that day was at about a quarter to eight in the evening so that Tasman would have been coming up to his anchorage in the twilight

and it would not have been far from dark when the ships anchored, increasing his natural caution in coming close in to a lee shore in an unknown land.

First Landing

When day dawned on December 12 the voyagers would have had a clear view of the coast. To the south lay forbidding cliffs, Humper's Bluff and Yellow Bluff, towering aloft and dominated by Cape Frederick Hendrick, with the swell of the sea rushing and swirling among the fissured crags and breaking wildly under the stiff steady breeze from the south-east. Nearly opposite the ships was Cape Paul Lamanon with its minor fortification of eroded dolerite, and between the two capes was to be seen the two-mile stretch of sand backed by low dunes that is now called North Bay. Under their lee lay Green Island, or, as it has been named for Tasman's pilot-major, Visscher Island. To the north-west lay Cape Bernier and to the eastward of it Maria Island. The whole presented the appearance of a wide sweeping bay, with the entrance to the Narrows showing as a smaller inner bay; the background was forested hills.

Early that morning Tasman sent seventeen men fully armed under the command of Pilot-Major Visscher to search for vegetables, wood and water. They went in two boats, the pinnace from the *Heemskercq* and the cock-boat from the *Zeehaen*. Rounding Cape Paul Lamanon, a prominent headland from which an ugly reef runs a considerable distance into the sea, the two boats passed through the Narrows into what is now known as Blackmans Bay but which is marked on the Gilsemans chart as "Fredricq Henricx Bay".

"They had rowed the space of upwards of a mile round the said point, where they had found high but level land, covered with vegetation (not cultivated but growing naturally by the will of God) abundance of excellent timber, and a gently sloping watercourse in a barren valley, the said water, though of good quality, being difficult to procure, because the watercourse was so shallow, that the water could be dipped up with bowls only."

Late in the afternoon the boats returned to the ships, the sailors bringing with them various samples of vegetables, which they had found growing in great abundance. Of these plants two are referred to in particular, one useful as a pot-herb and the other resembling samphire.

This spot can be fixed with certainty as the mouth of Boomer Creek, on the evidence of the sketch in Tasman's Journal, of the Gilsemans chart[3] and of our botanical survey of Blackmans Bay. It seems clear also that it was the only place where they landed and that other parts of the bay were not explored.

The statement that "they had rowed the space of upwards of a mile[4] round the said point, where they had found high but level land . . . and a gently sloping watercourse in a barren valley", means that their course to Boomer Creek was a direct one. The slope of the hills behind that part of the shore, forming a valley, must have led them to hope that water would be found there. On the return journey also they must have rowed direct; their instructions had been to return "speedily" and they were long overdue. Although they had been away a long time—not less than six hours—(high and low water soundings are recorded for the Narrows, 13 or 14 feet for the one—3 for the other) and possibly

as long as eight or nine hours (they left the ships "early in the morning" and returned "about three hours before nightfall", i.e., about 4.30 p.m.) this is amply accounted for by the extent of their activities. The details recorded in the journal show that they made many and careful observations on shore, not only at the landing place but "in the interior". Lastly there is the negative evidence that the Boomer Creek landing was the only one made and that they came and went direct, there being no mention in the log of any other landing or of other parts of the bay.

FIGURE 1 :—Chart of "Fredricq Henricx Bay", Tasman's Journal.
(J. E. Heeres, 1898)

For explanation of reference points see figures 3 and 4.

The coastline is recorded by a series of panoramic drawings showing contour, timber and type of shore. The whole of North Bay is drawn from one viewpoint, closely approximating to that used in Figure 4. The coast between the Narrows and Cape Bernier presents another single viewpoint. Separate points of observation are used to represent Prince of Wales Bay, Chinaman's Bay, and Cape Paul Lamanon. The inner circle of Blackmans Bay (compare Figure 3) is a composite of views from successive positions on the boat's course to the watering-place.

Three successive headlands at the northern end of North Bay, approaching the position of the Flag, resolve themselves on the spot into parallel ridges of hills rather than indentations. Cape Frederick Hendrik and Visscher Id. are outlined, and the outlet of the North Bay Lagoon is identifiable at the bottom left-hand corner of this plate.

Other details equally applicable to-day are the demarcation between the sandy beach of North Bay and the rocky shore guarding Prince of Wales Bay, the reefs of Cape Paul Lamanon, and the salt-marsh flat between the mouth of Boomer Creek and Boomer Island.

It may be noted that the only definite break shown in the shore-line is that which approaches closely to the position of Boomer Creek.

A number of drawings were made in January, 1943, from various points on the coast, with reed-pen and ink in a 17th century technique. These were used for comparison with maps, chart, and photographs. Two are shown in Figures 3 and 4.

Tasman's sketch of Blackmans Bay—or rather Visscher's, for the Pilot-Major went with the shore party and Tasman stayed with his ships—has always been regarded as a conventional chartmaker's representation of a coastline having a background of hills. But the chart *does* give a true picture of what the shore party actually saw, if we keep it in mind that these men were viewing the land as seamen do, from the sea, and that they were also seeing it from their boats, from only a few feet above sea level.

In reality Visscher's representation is remarkably accurate. From the boats' course between the Narrows and Boomer Creek (Fig. 3) the long east and west reaches at the upper end of the bay would not have been discernible: their existence would not even have been guessed at for there is no *visible* opening. Boomer Island appears to be part of the western shoreline of the bay, the land seeming to extend on from it right across to the southern shore. What they could see has been faithfully reproduced on the sketch: the point of Little Boomer, the gap in the shoreline to represent the mouth of Boomer Creek, the sugar-loaf of Boomer Island.

The Gilsemans chart (Fig. 2) guides us even more definitely to Boomer Creek, for it marks that part of the bay with the words " Water plaats ".

Our own examination of Blackmans Bay, along the whole shore of which we walked, only served to increase the certainty in our minds of the accuracy of log and charts. Details of description were found to agree with topography, and differences to have an explanation. We have already shown the form of the bay, as visible from the boats' course, to be that of their charts.

The lack of conformity of the open entrance shown on the chart and the Narrows of to-day is to be expected. The northern point is a sandspit, a feature which is notoriously subject to change from time to time under the action of the sea, winds, drainage from the land and so on.

Additional points of evidence became apparent as we walked. Firstly, Boomer Creek is the only permanent water along the northern shore line of the bay, between the Narrows and Boomer Island. In fact it was the only water to be found on the whole stretch of coast as far as Wilmot Harbour. Secondly, the description in the log of the watering-place agrees well with Boomer Creek and its surroundings: the " gently sloping watercourse in a barren valley "; the " high but level land " of the sandstone bluff on the eastern side of the creek overlooking the bay; and, lastly, the " waterplaats " growing where the creek flows into the bay, forming a salt-marsh at tide-level. Not only were they growing " in great abundance " but both sea-parsley and samphire occurred together there: nowhere else in Blackmans Bay is samphire to be found in anything like the same profusion and only here does sea-parsley occur as well as the samphire.

Second Landing

The next morning Tasman, accompanied by Supercargo Gilsemans and a number of musketeers, the oarsmen also being armed, went ashore in the same two boats as Visscher used the day before.

Photograph courtesy Mitchell Library, Sydney.

Figure 2: Portion of Gilsemans' Chart showing region discussed.

"We went to the south-east side of this bay" (that is, the sweeping bay of the sea coast between Cape Frederick Hendrick and Cape Bernier), says the journal. "Here we found water, it is true, but the land is so low-lying that fresh water was made salt and brackish by the surf, while the soil is too rocky to allow of wells being dug."

This would serve as an accurate account of the lagoon behind North Bay and the surrounding country to-day. In the south-east corner of that bay the water of the lagoon escapes to the sea over a wide, low-lying stretch of sand. If there is any sea running the surf breaks into the lagoon and from June to November, when the penned-up waters of the lagoon force a passage through the sandy flat, it becomes an arm of the sea into which the tide regularly flows. Beyond the sand the land is merely rock lightly covered with soil, if covered at all, rock which is the landward extension of the massive dolerite cliffs of Cape Frederick Hendrick.

So the boats returned waterless to the ships.

The Narrows
The Spit
RAV.M.C. 1943
1
2
3
4
5
6

FIG. 3

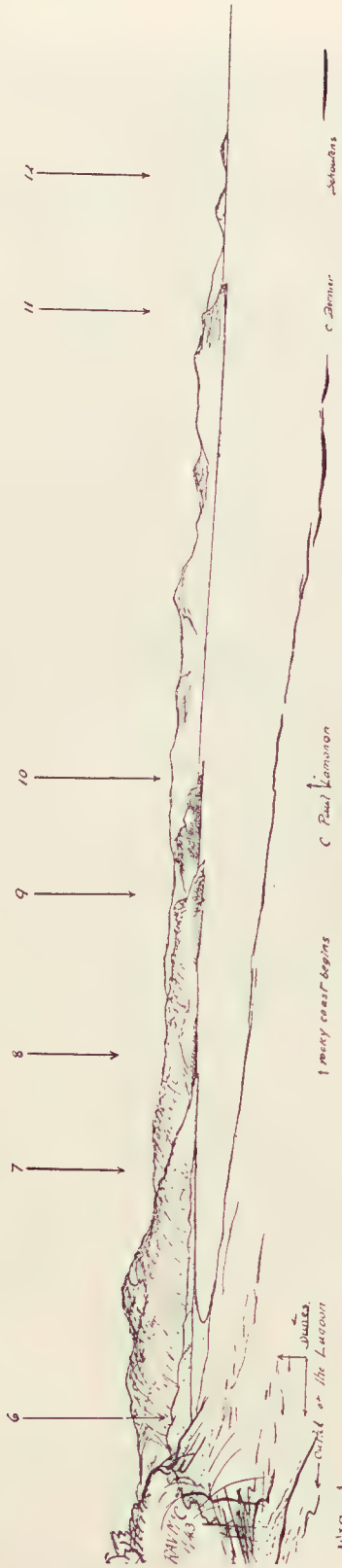
6
7
8
9
10
11
12
rocky coast begins
C Paul Lamonon
C Bernier
Schoutens
Dunes
Outlet of the Lagoon
RAV.M.C. 1943

FIG. 4

Annexation of the Territory

In the afternoon Tasman again took the two boats in the same direction, with the intention of landing there, hoisting the flag of his Prince on a pole with the Company's mark carved into it and taking possession; but the northerly wind, which had been blowing all day, had so increased in force that no landing was possible and the cockboat had to be pulled back to the ships while Tasman ran on with the pinnace to a small inlet which bore west-south-west of the ships. The surf being too high to admit of a landing the carpenter was ordered to swim ashore with the flag, which he did, planting the pole "about the centre of the bay".

The location of this "small inlet" has been the subject of much discussion. The opinion has been held generally that it was on the shore of Prince of Wales Bay that Master Carpenter Pieter Jacobsz set the Dutch flag (e.g., Gell, 1845; Walker, 1891; Lord, 1927); and it is there that the Tasman monument stands. Halligan (1926), however, decided that North Bay was the site. It has been considered also that Tasman's charts are very conventional and that it is hopeless to expect to get anyhing definite from them. It is worthwhile to pause here and recall Matthew Flinders' comment that "a chart is the seaman's great, and often sole guide": of what use would it be if inaccurate!

As we have already seen, Tasman's sketch is, in fact, remarkably accurate, and it can tell us a great deal about the place where the flag was set (Fig. 1). Not only is the flag shown on the chart but its position can be determined. Take as starting point Cape Paul Lamanon, marked by its reef extending seaward. Just to the south of the cape is a bay across which a reef is marked. This is clearly Prince of Wales Bay, protected by its wall of boulders. To the south of this bay is shown another, on the shore of which the flag is set. This is North Bay and here, on a shore protected from the northerly wind that was blowing so strongly that afternoon, the flag was raised.

Lastly, some further indication of the reliability of Tasman's map is obtained by comparing it with our sketch of the coastline as seen from the S.E. corner of North Bay (Fig. 4) where the lagoon makes its egress to the sea, and where the search for water failed on December 13th of 1642. The comparison is close, and it is sufficient to validate what has long been dismissed as conventional cartographic symbolism.

Figure 3: Blackmans Bay, seen from sea-level at the entrance through the Narrows. Compare with Chart showing the Watering-place, Dec. 1642. Jan. 1943.
Tasman's "Fredricq Hendricx. Bay". (Figure 2).
1. "high but level land" at the head of the bay.
2. position of creek and salt-marsh.
3. Boomer Island.
4. position of inner bay and isthmus, not discernible from this point.
5. The Spit.

Figure 4: North Bay and Coastline, as seen from the Outlet of the Lagoon at the S.E. corner of the bay, Jan. 1943. Site of Tasman's Second Landing, Dec. 1642. Compare with Chart, Figure 1.
6. sand dunes and beach.
7. beach ends and shore becomes steeply rocky.
8. position of the Flag.
9. southern headland of Prince of Wales Bay.
10. Cape Paul Lamanon.
11. Cape Bernier.
12. Cape Bouganville.

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Notes

1. The correction of the Old Style Calendar to the Gregorian Calendar was not made in the Netherlands until 1700, although it had been made in 1582 in Catholic countries. All Tasman's dates are therefore ten days less than the New Style dating; this is taken into account in the present narrative.—A. L. Meston.
2. The translation quoted in this paper is that by Heeres, J. E. (1898).—A. L. Meston.
3. I am indebted to the Librarian of the Mitchell Library, Sydney, for the following information about the Gilsemans chart and for the photograph reproduced in Figure 2:—

   "It was published in Dr. F. C. Wieder's Monumenta Cartographica, volume 4, as plate 97, and described as Original Chart of the Discovery of Tasmania, 24 Nov. to 5 Dec. 1642. The original is in the Atlas Storsch in the National Library of Vienna. In the letter-press Dr. Wieder examines the map to see what it discloses when compared with a special map in Tasman's own journal, the general chart of Jacobsen and that of Tasman and with the Vingboons map. He says:—'It is in the handwriting of Gilsemans who signed it "Isaac Gilsemans fecit". In the first place it strikes us that the land first sighted has not been put in longitude 163° 50′ according to the resolution of the ship's council, but in 165°. Secondly, the land sighted by the Zeehaen is drawn as a separate stretch of coast in latitude 41°, and is not on Tasman's special map nor on the two general charts nor on the Vingboons map. Thirdly, it delineates the entire field of Tasman's discoveries along the coasts of Tasmania, and therefore it must have been drawn up after 5 December, but it shows it one degree farther north than Tasman showed it on his map . . . The chart of Gilsemans is the original and most ancient map of Tasmania in existence, drawn by one of those who first saw its shores, if not the very person who first sighted land—and drawn most probably some days after the discovery . . . But historically the most interesting circumstance remains that the Zeehaen first sighted land, and that it was very likely Gilsemans himself who first saw it.'

   'This Gilsemans map is one of five hitherto unknown maps of Tasman's Australian voyages located by Dr. Wieder. The atlas which contains these maps is known also as the Great Atlas of Prince Eugene of Savoy. You are correct in assuming that Heeres did not know of it, because Wieder's discovery was made only a few years before the publication of the Monumenta Cartographica in 1932, but Heeres did write this:—"None of the sources known to the present goes to show that it was Zeehaen and not the Heemskerck, that first made the discovery of Van Diemen's Land. Perhaps the reason why this name is found in Visscher's map of the world is that the draftsman used a chart no longer extant, drawn up aboard the Zeehaen, and expressly recording the fact that the discovery had been made on board the said vessel." And so, though he did not know of the Gilsemans map, he made an accurate guess at the existence of it, or at any rate of one by somebody on board the Zeehaen."—A. L. Meston.
4. The Dutch mile of the 17th century was 1/15 of a degree of latitude, i.e., 4 English nautical miles.—A. L. Meston.

Pap. & Proc. Roy. Soc. Tasmania, Vol. 87 (15th August, 1953)

The Urogenital System of the Dasyurin ae and the Thylacininae (Marsupialia, Dasyuridae) (1)

by

Joseph Pearson

and

J. M. de Bavay

(WITH 14 FIGURES)

Summary

The present paper deals with the female urogenital system of *Dasyurus, Dasyurops, Sarcophilus* and *Thylacinus.*

I. Introduction

It is proposed to deal with the female urogenital system of the family Dasyuridae with the exception of that of the sub-family Phascogalinae which was described in a previous paper in which *Antechinus* was used as a representative of the sub-family (Pearson and de Bavay, 1951). Where it is found necessary to make broad comparisons of the various sub-families in the course of the present discussion use will be made of the conditions already found in *Antechinus.*

The urogenital system of *Dasyurus* and *Sarcophilus* was described somewhat summarily in an earlier paper (Pearson, 1945) but the observations then made were based solely upon dissections, a method which was realized at the time to be inadequate. In particular the method failed in the assessment of the size of the pseudovaginal gap, which further researches with more precise methods have now been able to correct. Owen (1868) stated that in *Dasyurus* " The mesial culs-de-sac of the vaginae descend to the urogenital passage and are connected to it but do not communicate with it or with one another ". In the first paper of this series Pearson (1945) stated that " In Australian forms [Polyprotodonts] which have achieved parity the pseudovaginal gap hardly exists . . . In young females the pseudovaginal gap is present and gradually becomes reduced as maturity approaches ".

[1] The investigations dealt with in this paper have been assisted by grants from the Trustees of the Commonwealth Science and Industry Endowment Fund and the Tasmanian State Government.

Both these opinions need to be amended in the light of the results given in the present paper which are based upon careful examination of serial sections. These have revealed beyond a shadow of doubt that the median vaginal culs-de-sac of the Dasyuridae do not extend caudally as far as the urogenital sinus at any period of life. That is to say, a definite pseudovaginal gap is present in all members of the Dasyuridae, varying in length from 40 per cent to about 60 per cent of the antero-posterior length of the vaginal complex (Table 1). Of the five superfamilies of the Marsupialia only one, the Phalangeroidae, contains some species in which the two culs-de-sac (or a single fused cul-de-sac) reach the urogenital sinus and, in a few of the more specialized forms, may acquire an actual connexion with it.

A further point of some significance revealed by the examination of these serial sections is the true extent of the urethra, as well as the precise level at which the urethra opens into the urogenital sinus. The urethra is the median efferent tube by which the contents of the urinary bladder are conveyed to the urogenital sinus. It begins anteriorly at the level of the entry of the ureters into the neck of the bladder and terminates caudally at its connexion with the urogenital sinus. Dissections of dasyurids would give the impression that the urinary bladder opens directly into the sinus and that the urethra is almost non-existent. The measurements given in Table 1, however, show that in five specimens of *Dasyurus* and one of *Dasyurops* the relative length of the urethra in terms of the antero-posterior length of the vaginal complex varies from 28 per cent to 76 per cent with a mean relative length of 50 per cent. This rather large variability may be due to one or more causes, such as, the effects of allometric growth at different stages in the life history, or to the ordinary variability found in animals of the same species, or to the condition of the urogenital system at different oestrous stages, or even to the irregular contraction brought about by variability in fixation and preservation. By comparison the mean relative length of four specimens of *Antechinus* was 38 per cent (Pearson and de Bavay, 1951). Though it is clear that reliable conclusions can hardly be drawn from such a small sample, it is nevertheless sufficient to show that the urethra in these genera is much longer than was previously thought to be the case.

These important features of marsupial morphology could not have been revealed by recourse to ordinary dissections alone, at any rate in the Dasyuridae where the vaginal complex is so small that more refined and exact methods are required. It is for this reason that serial sections have always been used to supplement, and correct where necessary, the information previously gained by mere dissections.

II. Material and Methods

The results described in the present paper are based upon the examination of serial transverse sections of the following species.

Sub-family **Dasyurinae**

1. *Dasyurus quoll* (Zimmermann, 1777).
2. *Dasyurops maculatus* (Kerr, 1792).
3. *Sarcophilus harrisii* (Boitard, 1841).

Sub-family **Thylacininae**

4. *Thylacinus cynocephalus* (Harris, 1808).

The numbers given to the specimens dealt with do not refer to numbers recorded in the Tasmanian Museum register but to special numbers given to specimens which were preserved, and in many cases dissected and sectioned in the course of the present investigations. To prevent any ambiguity the preserved material, as well as the large collection of serial sections, will be kept apart and will be known as the Pearson collection. This collection of serial sections of Australian marsupial material is an important one and is perhaps one of the most comprehensive of its kind to be found in any biological institution. It is hoped that this material, which at the present time (1953) is housed in the Tasmanian Museum, will be made available to other research workers when the present work has been completed.

The sections, which were cut transversely at thicknesses varying from 10 μ to 15 μ, were stained with Ehrlich's haematoxylin and counterstained with Eosin. Graphic reconstructions have been made from these serial sections and occasionally three-dimensional models have been made. In the case of fresh material the organs to be sectioned were dissected, and then removed and fixed in Bouin's fluid. With rare species, however, it was sometimes found necessary to make use of material which originally had been preserved in alcohol of unknown strength fifty or more years ago. This applied particularly to *Thylacinus* material which, however, in spite of this disability came through the microtome ordeal fairly well and revealed somewhat inadequately the essential structures though histological details were not revealed as clearly as might have been desired. In such cases of poorly preserved material sections were sometimes cut as thick as 20 μ.

III. Descriptions

It will be convenient to consider the four species under examination in three separate groups, viz:—

Group 1. *Dasyurus quoll* and *Dasyurops maculatus.*
Group 2. *Sarcophilus harrisii.*
Group 3. *Thylacinus cynocephalus.*

In order to obtain a full picture of the condition of the urogenital system throughout the Dasyuridae a previous paper on *Antechinus*, representing the Phascogalinae, should be consulted (Pearson & de Bavay, 1951).

Group 1. Dasyurus and Dasyurops (Figs. 1, 5-8)

There are only two species of Native Cat indigenous to Tasmania. As there appear to be no essential differences between the female urogenital system of the two forms, it is proposed to consider them together.

Uteri (ut.)

An examination of figs. 1-4 shows that the uterus is built on somewhat similar lines throughout the Dasyuridae. That is to say, the two fusiform uterine bodies vary in the amount of tilt displayed towards the median line. In extreme cases they lie almost parallel to the antero-posterior axis and in the other extreme such as is shown in figures 1 and 3 the caudal ends of the two uterine bodies approach close to each other. There may

be considerable variability in this respect in different individuals of the same species. The caudal extremities of the uterine bodies are linked with the vaginae by a pair of narrow uterine necks which are clearly separated from the uteri and which in combination present a characteristic Y-shaped appearance.

It should be noted that in the measurements given in Table 1 those of the uterus have been omitted, since the dimensions of this part of the urogenital system exhibit considerable variation at different periods of the oestrous cycle and will certainly vary greatly at different stages in the life of the animal. It would be difficult, therefore, to attempt to give a reliable and helpful picture of the normal dimensions of the uteri.

Vaginal complex

The vaginal complex consists of the posterior region of the two Müllerian ducts (1). In the simplest condition each duct has a double bend. The proximal portion of the first bend receives the os uteri and passes caudally near the median line as the *cul-de-sac (m.v.c.)*. The right and left culs-de-sac are in contact mesially but are separated by a median septum between the two chambers. In certain cases this septum may be partially or completely destroyed in mature specimens, but more often than not in the more primitive members of the Dasyuroidea the septum remains inviolate. The second section of each vagina forms the distal portion of the first bend and the proximal portion of the second bend. It is the *anterior vaginal canal (a.v.c.)* and in its simplest condition passes anteriorly and outward and links the cul-de-sac with the *lateral vagina (l.v.)*. This third element of the vaginal complex forms the distal portion of the second bend and runs caudally, veering in its course towards the median line. The two lateral vaginae open together into the urogenital sinus.

As already stated, the relative size of the vaginal complex of the Dasyuridae is surprisingly small, as can be judged from the measurements given in Table 1.

These measurements show that in seven specimens of the four genera dealt with in the present paper, the relative length of the urogenital sinus in comparison to the length of the vaginal complex varies from 224 per cent to 845 per cent with a mean of 500 per cent. These figures reveal the relatively small vagina in these genera. In four specimens of the genus *Antechinus* dealt with in a previous paper, the figures varied from 221 per cent to 298 per cent with a mean of 258 per cent. The total number of specimens examined was much too small to give a reliable result but the measurements tend to emphasize two points, first, that the vaginal complex of the Dasyuroidea is very small by comparison with the length of the urogenital sinus, and secondly that the disparity is not so great in *Antechinus* as in the four genera under consideration in the present paper. In this latter respect *Antechinus* would appear to approach more closely to the condition found in the Didelphidae. The photographs given by

(1) This statement needs some qualification as it is generally conceded that the most caudal region of the marsupial vaginae may be composed partly or entirely of elements which are not of Müllerian origin. However there is a lack of unanimity as to what these elements are. The present investigations have thrown entirely new light upon this question and it is proposed to deal with it in a paper which is now being prepared.

TABLE 1

Measurements of the parts of the female urogenital system of the specimens used in the preparation of the present paper.

	ae mm.	*ac* mm.	*ce* mm.	*de* mm.	*ef* mm.
Dasyurus, T.M. 221	2·80	1·29 (46%)	1·51 (54%)	2·15 (76·8%)	?
Dasyurus, T.M. 174	4·98	2·71 (54·4%)	2·27 (45·6%)	3·09 (62%)	?
Dasyurus, T.M. 88	18·30	9·00 (49·2%)	9·30 (50·8%)	5·53 (30·2%)	41·00 (224%)
Dasyurus, T.M. 282a	7·86	4·64 (59%)	3·22 (41%)	2·23 (28·4%)	33·70 (429%)
Dasyurus, T.M. 219	7·07	4·25 (60%)	2·82 (40%)	3·02 (42·7%)	45·36 (641%)
Dasyurops, T.M. 306	5·64	2·31 (41%)	3·33 (59%)	2·92 (51·9%)	47·66 (845%)
Sarcophilus, T.M. 267	10·70	2·52 (23·6%)	8·18 (76·4%)	5·29 (49·4%)	58·72 (548%)
Sarcophilus, T.M. 293	1·70	2·60 (15·3%)	1·44 (84·7%)	1·05 (61·7%)	?
Sarcophilus, T.M. 50	12·85	4·02 (31%)	8·83 (69%)	5·59 (43·5%)	?
Thylacinus, 292 (Melbourne)	2·31	0·28 (12·1%)	2·03 (87·9%)	1·83 (79·2%)	8·05 (350%)
Thylacinus, 199 (Sydney)	5·91	1·44 (24·4%)	4·47 (75·6%)	4·56 (77·1%)	27·00 (458%)

ae—Antero-posterior length of vaginal complex.
ac—Anterior extremity of vaginal complex to caudal end of cul-de-sac.
ce—Pseudovaginal gap.
de—Length of urethra.
ef—Length of urogenital sinus.

NOTE.—The percentages given in brackets refer to the proportionate length of each part in relation to the antero-posterior length of the vaginal complex (*ae*).

Hill and Fraser (1925, Plates I and II) present an admirable picture of the urogenital organs of various species of Didelphidae, but it is impossible to determine from them the precise point at which the vaginal complex ends and the urogenital sinus begins and it is equally difficult to be assured of the exact position of the clitoris. Nevertheless from these photographs it is possible to make a broad determination of the relative antero-posterior measurements of both vaginal complex and urogenital sinus. This as already stated, would be closer to those of *Antechinus* than to those of the remaining Dasyuroids which have been examined. This lends support to

the suggestion made by the present authors in an earlier paper that *Antechinus* is perhaps one of the most primitive of Australian marsupials if the evidence of the urogenital system may be used as a reliable criterion. If due allowance is made for the small number of specimens which have been measured it may be permissible to conclude that the greater relative length of the urogenital sinus in *Dasyurus* and the other genera dealt with in the present paper is perhaps evidence that on this single character *Dasyurus* and the associated genera may have departed from the prototypal condition, but not in the direction taken by some of the more highly specialised Australian marsupials in which the urogenital sinus becomes shorter than the antero-posterior length of the vagina.

It is interesting to compare the condition of the vaginal complex in No. 282A which is a parous specimen with that in No. 88 which, though of large size, is non-parous. In No. 88 both the anterior vaginal canals and the culs-de-sac have a very small lumen with an irregular shape when seen in transverse section (figs. 8A and B). These transverse sections reveal the fact that in No. 88 the thick muscular walls of the lateral vagina are made up of five or six well defined longitudinal ridges. The walls of each cul-de-sac have five longitudinal ridges and in each anterior vaginal canal the ridges are more numerous and more complicated. Moreover, the lumina of these three portions of the vagina are very constricted. The walls of the culs-de-sac are very thick and the right and left sides are separated by a solid mass of connective tissue which is much thicker than a normal septum. In 282A, on the contrary, the walls of both anterior vaginal canals and culs-de-sac are tenuous and the cavities are spacious and the longitudinal ridges referred to above are feebly developed and project but a short distance into the vaginal cavity. The right and left culs-de-sac are separated by a very thin wall consisting of a double layer of epithelium separated by a thin layer of connective tissue. This marked difference between the appearance of the vaginal complex in No. 88 and No. 282A would appear to be entirely due to the effects of distension in the latter specimen caused by parturition.

Culs-de-sac (m.v.c.)

In both *Dasyurus* and *Dasyurops* each uterine neck opens into the roof of the cul-de-sac near the tip of the swollen uterine papilla. The cul-de-sac ends blindly at its caudal end and at its anterior end passes imperceptibly into the anterior vaginal canal which runs forward immediately below the uterine neck.

Each cul-de-sac represents the proximal region of the vaginal complex and it is here that each os uteri opens into the vagina. In fully mature specimens each os uteri is situated near the tip of its uterine papilla. Theoretically the anterior or proximal region of each cul-de-sac is situated at the level of the os uteri but because of the growth and protrusion of the uterine papilla into the cavity of the cul-de-sac, the os uteri is carried a short distance caudally, leaving behind a very small irregular chink of the main cul-de-sac which surrounds a part or the whole of the papilla. Therefore, this almost isolated portion of the cul-de-sac represents the extreme anterior level of the cul-de-sac. Fig. 6 should serve to make this point clear. In very young specimens the uterine papillae are rudimentary or absent altogether in which case the anterior extremity of the cul-de-sac would be at the same level as the os uteri. This is the case in *Dasyurus* No. T.M. 221.

Usually in all immature and non-parous adult specimens the two culs-de-sac are completely separated from each other by a well-defined septum. In certain cases, however, the septum may be broken, a condition which has been considered to be the result of parturition. Flynn (1912) discussed this question at some length in the case of *Trichosurus* and concluded that a broken septum implied that the animal was parous. However, he was obliged to modify this view in the light of his later discovery of the presence of a thick unbroken septum in a *Trichosurus* which carried a pouch embryo. This confirmed van den Broek's observations on *Didelphis* in which one specimen with pouch young had a complete septum while another, which also carried pouch young, had a perforated septum. Flynn, therefore, suggested that in those parous females in which the septum was torn pseudovaginal parturition had taken place, while in those in which the septum was unbroken parturition had taken place through the lateral vaginae. New evidence on this point is now given in Table 2 from which it will be seen that in *Dasyurus* No. T.M. 282a, which carried four pouch young, the septum was complete, while in *Dasyurus* No. T.M. 174, a young non-parous specimen, the septum was broken, both phenomena being precisely the reverse of what had previously been regarded as the normal state of affairs.

It would appear, then, that Flynn's conclusions on this question cannot be sustained, since a broken septum does not necessarily imply that parturition has taken place. A broken septum in a non-parous female may possibly be explained as having been due to abnormal intra-vaginal fluid pressure during pseudopregnancy or during the height of the oestrous period. An unbroken septum in a parous specimen, on the other hand, may be simply due to the abnormal thickness and strength of the septum as may be seen in the Phascogalinae, and this may have been the normal condition when pseudovaginal parturition was first established in the Marsupialia. It is clear that in the most highly specialized members of the Phalangeroidea, where a permanent connexion between the cul-de-sac (median vagina) and the urogenital sinus is established. the primitive septum breaks down, as it does in the eutherian vagina, so as to afford as wide a passage as possible for the embryo on its hazardous journey to the exterior.

Anterior vaginal canals (a.v.c.)

Each cul-de-sac opens distally into the anterior vaginal canal which is second in sequence of the three sections of the vagina. The position of the anterior vaginal canal in relation to the cul-de-sac is perhaps seen in its least specialized condition in *Antechinus* (see Pearson and de Bavay, 1951). In that case the canal arises ventro-laterally from the cul-de-sac and takes a wide outward and forward sweep before making a sudden caudal turn into the lateral vagina. In *Dasyurus* and *Dasyurops*, however, the anterior vaginal canals take a somewhat different course. Each canal emerges from the *anterior* extremity of the cul-de-sac immediately below the base of the uterine papilla and proceeds cephalad below the uterine neck. The right and left canals run side by side as shown in fig. 7, then diverge and make a sharp turn first outward and then caudally to merge into the lateral vaginae, which veer gradually towards the middle line in their caudal progress until they meet and coalesce at their point of entrance into the roof of the anterior end of the urogenital sinus.

Lateral vaginae (l.v.)

This region of the vaginal complex calls for special comment in two important respects and the following remarks may be said to apply equally to all four genera dealt with in this paper.

(*a*) *Periodic occlusion of the lateral vaginae.* In some cases occlusions in the lateral vaginae occur near their caudal ends (see Table 2). Such occlusions are well known throughout the Marsupialia and have been referred to by various authors. (e.g., Hartman, 1923). The occlusions appear and disappear at intervals during the lifetime of an individual and this variability is probably due to changes in the oestrous condition. The lateral vaginae functioned as the birth passage in the prototypal marsupials but at a later stage in the evolution of the Marsupialia the development of the characteristic double kink probably made these ducts unsuitable for parturition. In recent marsupials parturition takes place almost invariably by way of the median pseudovaginal passage, a method which provides one of the most amazing stories in the history of mammalian embryology. In consequence of this change the lateral vaginae now have only one main function, that of storing the spermatozoa received during oestrus. These improvised spermathecae become more efficient if they are provided with plugs at their caudal extremities and the periodic occlusions serve this purpose. When the full story is known it will probably be found that these vaginal occlusions develop immediately after oestrus and last through the metoestrus stage and in exceptional circumstances perhaps through the anoestrous stage. Normally, however, the lateral vaginae are probably patent throughout the anoestrous and proestrus stages. It is not unlikely that in certain of the more specialized marsupials such as the Kangaroos, a single supply of spermatozoa may be retained in the spermathecae for a relatively long period and in such circumstances would be available to fertilize two different sets of ova (see Wood Jones, 1923, p. 74).

This phenomenon of occlusion was observed by Flynn (1911) in an adult female specimen of *Sarcophilus* with three pouch young. He concluded that this " obliteration " of the caudal region of the cavity in each lateral vagina was caused by the mechanical action of compression or actual tearing due to the passage of the embryos down the pseudovagina, which lies medial to the lateral vaginae and in close proximity to them. This single example of occlusion observed by Flynn was confirmed by Hill and Fraser (1925) in several species of the family Didelphidae and has also been found in the course of the present investigations in the genera *Dasyurus, Dasyurops, Sarcophilus* and *Thylacinus* as well as in other marsupials. Table 2 records the incidence of occlusion in these four genera as observed during the present inquiry. Seven out of the eleven specimens examined showed occlusion of the lateral vaginae and of these seven specimens with occlusions four were definitely immature and non-parous and another was doubtfully non-parous. This evidence very clearly disposes of Flynn's contention that the occlusions are caused by the effect of pseudovaginal parturition.

(*b*) *Vestigial Wolffian ducts (W. d.).* The second important feature of the posterior region of the lateral vagina is the occasional persistence of the caudal remnant of the Wolffian duct, which after ceasing to function as the duct of the mesonephros undergoes degeneration in the female.

TABLE 2

Information regarding specimens of the Dasyuridae used in the preparation of the present paper.

	Maturity	Head & Body (D.C.L.)	Parity	Condition of lateral vagina	Vestigial Wolffian duct	Septum between culs-de-sac
Dasyurus T.M. 221	immature, ¼ grown pouch young	23·5 cm.	non-parous	occluded	present	complete
Dasyurus T.M. 174	immature	32·2 cm.	non-parous	occluded	present	broken
Dasyurus T.M. 88	fully grown but apparently non-parous	35 cm.	non-parous	patent	present	complete
Dasyurus T.M. 282A	was carrying 4 pouch young	33 cm.	parous	patent	present	complete
Dasyurus T.M. 219	was carrying 3 pouch young	?	parous	occluded	present	broken
Dasyurops T.M. 306	one nipple of pouch very large. Rest small	?	parous	occluded	present	complete
Sarcophilus T.M. 267	young adult	?	non-parous	occluded	present	complete
Sarcophilus T.M. 293	pouch embryo	11·7 cm.	non-parous	patent	present	complete
Sarcophilus T.M. 50	adult	60·5 cm.	probably parous	occluded	present	complete
Thylacinus 292 (Melbourne)	pouch young	13·1 cm.	non parous	occluded	present	complete
Thylacinus 199 (Sydney)	advanced pouch young	21·2 cm.	non parous	patent	present	complete

Van den Broek (1906) showed that the middle part of the Wolffian duct disappears while the cranial and caudal sections remain. In some instances it is probable that the Wolffian ducts disappear completely in the adult. On the other hand in the course of the present investigations one of us (de Bavay, 1951) has recorded the presence of a persistent Wolffian duct in an adult female specimen of *Tarsipes*. This was undoubtedly an abnormality. As already mentioned briefly in a previous paper (Pearson and de Bavay, 1951) a Wolffian remnant is present in the Dasyuroidea and an examination of Table 2 reveals that in all eleven specimens upon which the conclusions of the present paper are based a Wolffian vestige was present. Both the specimens of *Thylacinus* were pouch young and, as mentioned later, no knowledge whatsoever of the condition of the urogenital system in mature specimens of this rare form has been made known to the world, so that it is not possible to say whether the Wolffian remnant persists in adults of *Thylacinus*, but it can be stated without a shadow of doubt that in the adult females of the genera *Dasyurus*, *Dasyurops* and *Sarcophilus* the Wolffian duct is recognizable as a component of the caudal portion of the lateral vaginal. On the other hand in *Antechinus* only one out of five specimens examined by serial sections showed signs of the Wolffian remnant. (Pearson and de Bavay, 1951). It is of interest to note that in their exhaustive examination of several species of the Didelphidae, Hill and Fraser (1925) made no mention of the presence of this vestige, and the single female specimen of *Didelphis virginiana* examined by the present authors also showed no signs of the Wolffian remnant. This interesting problem is under consideration at present and a preliminary note, as yet unpublished, was submitted to Section D of the Australian and New Zealand Association for the Advancement of Science at the Sydney meeting in 1952.

Urethra (Ureth.)

This has already been discussed above. It is a median tube which runs in a caudal direction from the neck of the bladder immediately ventral to the culs-de-sac and the "pseudovagina". Its caudal limit may be regarded as the point of confluence of the two dorso-laterally placed lateral vaginae and the three ducts thus join to form the urogenital sinus. As already seen the length of the urethra is variable but normally may be said to be about one half of the antero-posterior length of the vaginal complex.

Urogenital Sinus (u.g.s.)

As already seen, the sinus is very long in the two genera now being considered (see Table 1). The clitoris is arbitrarily regarded in these studies as the posterior limit of the urogenital sinus, but in *Dasyurus* and *Dasyurops* the clitoris is not so clearly defined as it is in most marsupials. Immediately posterior to the clitoris the urogenital sinus passes into the cloaca.

Group 2. **Sarcophilus** (Figs. 2, 9-11)

It is proposed to deal only with those anatomical features in which *Sarcophilus* departs from the usual dasyure arrangement.

Uteri (Ut.)

It will be seen from fig. 2 that the two fusiform uterine bodies are connected with the vaginae by means of the Y-shaped uterine neck which

have two proximal convergent arms of abnormal length and a very short distal portion consisting of right and left elements which run side by side to open into the vaginae by means of the ora uterorum. This abnormally long uterine neck obviously puzzled Mackenzie (1919) who regarded it as the proximal portion of the vaginal system. This interpretation can be refuted on at least three grounds:—

1. The nature of the epithelium of the uterine necks.
2. The position of the ora uterorum on the swollen uterine papillae at the distal extremities of the uterine necks.
3. The evidence provided by a comparative study of the urogenital system of the Marsupialia.

Vaginal Complex

This consists on each side of the usual three sections, first the cul-de-sac which is the most proximal portion of the vagina. In this region the right and left sides meet in the middle line though separated by a septum. This is followed by the anterior vaginal canal which, in *Sarcophilus*, is not easily recognizable and last the lateral vagina which proximally is connected with the anterior vaginal canal and opens distally into the urogenital sinus along with its counterpart from the other side.

Culs-de-sac (m.v.c.)

Flynn (1911) has given a detailed account of the proximal portion of the vaginal complex. His description, however, is difficult to follow owing to the absence of drawings reconstructed from his serial sections. In the present paper this omission has been made good and it is hoped that the description which follows, combined with figs. 9, 10 and 11, will clarify this matter.

The right and left culs-de-sac lie side by side and are separated by a well-developed median septum. Mackenzie (1919) stated that the septum is broken in some specimens but no such instance has been noted in the course of the present inquiry, and in the case of the parous adult specimen of *Sarcophilus* described by Flynn (1911) the septum was intact. However, the variability of the septum in *Dasyurus* justifies the assumption that *Sarcophilus* and *Dasyurus* may be similar in this respect and thus lend support to Mackenzie's statement.

Each cul-de-sac consists of two portions, a proximal tubular chamber into which the os uteri opens and a larger distal portion, connected with the former by a narrow opening. This distal portion which may be regarded as the cul-de-sac proper expands into a relatively large and irregularly shaped chamber which ends blindly at its caudal extremity and in its ventro-lateral region passes imperceptibly into the lateral vagina.

The proximal chamber of the cul-de-sac was designated by Flynn, the " median vaginal neck " which according to him, " is seemingly quite distinct . . . from the median vaginal cul-de-sac ". It is difficult to understand this statement as there would appear to be no doubt that the median vaginal neck is part of the cul-de-sac and actually opens into it. Throughout the present series of papers each cul-de-sac is regarded as that part of the vaginal system which is situated medially and lies immediately caudal to the os uteri. In those cases where the os uteri is situated near the tip of the uterine papilla the anterior limit of the cul-de-sac is regarded as being at the base of the papilla. The right and left culs-de-sac lie

apposed to each other and, in the specimens given in Table 2, are completely separated from each other by a median septum. This consists of the epithelium of each cul-de-sac, and an intervening layer of connective tissue of variable thickness.

Anterior vaginal canal (a.v.c.)

In an earlier paper one of us (Pearson, 1950) traced the variation in the disposition of the three sections of the marsupial vagina, viz., cul-de-sac, anterior vaginal canal and lateral vagina. Hill (1899) first coined the term " anterior vaginal canal " for a specialized narrow duct which linked each vaginal caecum with the common cul-de-sac in *Perameles*. In *Antechinus, Dasyurus* and *Thylacinus* Hill's anterior vaginal canal forms the proximal arm of the loop which is so characteristic of the more typical marsupials. In this respect *Sarcophilus* is not typical and it requires an effort of the imagination to locate this part of the vaginal complex. This difficulty may be resolved, however, if one defines the canal as being that part of the vagina which links the cul-de-sac with the lateral vagina.

Lateral vaginae (l.v.)

This portion of the vaginal complex calls for no special comment. But the generalized remarks made in the case of *Dasyurus* and *Dasyurops* as regards the spermathecal function of the lateral vaginae, as well as the presence of occlusions at certain stages in the oestrous cycle, and also the retention of a Wolffian remnant throughout life apply equally in the case of *Sarcophilus*.

Urogenital sinus (u.g.s.)

It has already been mentioned that *Sarcophilus* and the other members of the Dasyuroidea are characterized by the presence of a relatively long urogenital sinus. It is probably true that by comparison with the antero-posterior length of the vaginal complex the urogenital sinus of the Dasyurinae, represented by *Dasyurus, Dasyurops* and *Sarcophilus* is longer than in the Phasogalinae, represented by *Antechinus*. In this respect the latter sub-family would seem to conform with the members of the primitive super-family Didelphoidea. However, the few measurements dealing with this question given in Table 1 are obviously inadequate and perhaps too much should not be made of this, but it is our view based upon the condition found in primitive genera such as *Didelphis* and *Antechinus* that the prototypal marsupial had a urogenital sinus which was of considerable length though perhaps not so long as in *Dasyurus* and *Sarcophilus*. It is found that the least specialised members of the Phalangeroidea have a relatively long sinus which becomes shorter in the Macropodidae and still shorter in the Potoroidae. In one of his papers on *Sarcophilus* Flynn (1910), dealing with the long urogenital sinus present in that genus, stated that this was one of the points in which " the genital organs of *Sarcophilus* are relatively more advanced than those of Perameles " (where the sinus is almost non-existent). In earlier papers Hill (1899, 1900) had also expressed the view that the short sinus was a primitive condition, but there is abundant evidence to claim that the exact opposite is probably true, namely, that the very short urogenital sinus of *Perameles* is one of several characters in that genus which show that the bandicoots are an aberrant group and not primitive, as Hill and Flynn claimed. (see Pearson, 1945, pp. 76-80).

Group 3. **Thylacinus** (Figs. 3, 12-14)

This interesting marsupial is confined to Tasmania though it once lived on the Australian mainland. It is now, unfortunately, very rare and almost extinct. So far as is known a specimen has not been captured for at least twenty-five years though from time to time reports come in of specimens having been seen. Perhaps a dozen such reports have been received at the Tasmanian Museum in the last twenty years, many of them being most unreliable. However, until about 1920 *Thylacinus* was occasionally killed or captured and there can be no doubt that in the early settlement days in Tasmania, it was fairly common, so common in fact that it proved to be a menace as a sheep-slayer and a price was actually placed upon its head. Looking back, it is amazing to contemplate that no Australian zoologists took advantage of the presence of this rare form to make a serious study of its anatomy while specimens were readily procurable. The result has been that no account of the female urogenital system has hitherto been published. The only account of its internal anatomy was made by Professor D. J. Cunningham (father of Admiral of the Fleet Viscount Cunningham) from material collected by the "Challenger" Expedition. Unfortunately Cunningham's admirable paper dealt with a male specimen. The present account loses much of its value since it is based upon the examination of immature specimens, one a fairly advanced pouch young, No. 199, having a dorsal contour length (head and body without a tail) of 31·2 cm. This specimen was kindly lent by the authorities of the Australian Museum, Sydney. Another specimen, a pouch young, No. 292, having a D.C.L. of 13·1 cm. (head and body, minus tail) was placed at our disposal through the kindness of the authorities of the National Museum, Melbourne. These specimens had been preserved in spirit without any special process of fixation and as they are about fifty years old it was not to be expected that the serial sections would be very revealing. However, it was found that the sections proved to be sufficiently informative to enable a reasonable interpretation to be made of the condition of the urogenital system. But such an interpretation being based upon immature material loses much of its value and we are still ignorant of the precise arrangement of the mature female urogenital system of *Thylacinus*.

The condition of the female urogenital system in the two pouch embryos which have been examined does not disclose any striking features. It can be said that both specimens show a general arrangement of the urogenital system as might be seen in most marsupials at some early stage in their development. Fig. 3 shows the general design which calls for no special observations. In figs. 12 and 13 the vaginal region is shown in greater detail and this is further elaborated in the diagrams given in fig. 14. These diagrams are not as satisfactory as might have been desired but the poor condition of the specimens precluded the use of detailed drawings.

Uteri (ut.)

The general arrangement is disclosed in fig. 3. The two uteri are splayed outward from their distal extremities which meet in the middle line. Here each uterine body passes sharply into the uterine neck, the right

and left necks running side by side in a caudal direction for a distance equal to one-half the length of each uterine body. At their distal ends the two uterine necks pass imperceptibly into their respective culs-de-sac. It is noteworthy that the ora uterorum are not situated on uterine papillae. No significance should be attached to this feature which may be regarded as common to all marsupials in the immature condition.

Vaginal Complex

The general disposition of the vaginal region follows the simple conventional double loop arrangement which forms the basis of the vaginal plan of all marsupials. That is to say, the proximal portion, the culs-de-sac (right and left, separated by a septum in the median line) which end as blind sacs at their caudal extremities; a second portion, the two anterior vaginal canals which pass forward and outward from each cul-de-sac; and a distal portion at each side continuous with the anterior vaginal canal which turns sharply in a caudal direction to form the lateral vagina.

Culs-de-sac (m.v.c.)

These are well defined and have a length equal to about one-fifth of the antero-posterior length of the vaginal complex. The two culs-de-sac are separated by a well developed septum. As stated earlier, the anterior limit of each cul-de-sac is at the level of the os uteri when the uterine papillae are absent. It is important to note that even in these extremely immature specimens the culs-de-sac have reached a higher stage of development than that found in mature specimens of *Antechinus*. This might be taken to indicate that the mature females of the genus *Thylacinus* may possess a more highly developed type of urogenital system than that known to occur in the phascogales. This is a justifiable assumption as the experience gained in the course of the present intensive investigation indicates that the nature of the female urogenital system serves as a valuable pointer in the somewhat difficult question of marsupial phylogeny. Tate (1947) has suggested that *Thylacinus* and the small New Guinea phascogale *Murexia* are the survivors of a very old line, and accordingly has placed the former genus in the sub-family Phascogalinae alongside *Murexia,* which may startle some systematists. But he has been careful to point out that if *Thylacinus* is descended from a small generalized *Murexia* both the modern representatives are now far removed from their primitive ancestor and from each other, though both retain certain cranial features in common. Both have travelled a long way and to a great extent in different directions. Fundamentally there is nothing startling in this concept as most biologists have been brought up on the dictum that all marsupials have been derived from small arboreal ancestors. However, the evidence of a mature female *Thylacinus* might well show that the vaginal system of that form is sufficiently advanced to justify placing *Thylacinus* in its own separate sub-family, as is generally accepted by systematists on other grounds.

Anterior vaginal canals (a.v.c.)

Each canal leaves the antero-lateral region of the cul-de-sac and passes forward and outward lying on the outer side of the uterine neck. The cavity of the canal is laterally compressed. At its most anterior region it is confluent with the lateral vagina.

Lateral vaginae (l.v.)

Each lateral vagina passes caudally in the normal manner and approaches nearer to the middle line as it pursues its course.

In specimen No. 292 the cavity of the canal is occluded near its caudal end. In No. 199 the entire cavity remains patent. In both specimens the vestiges of the Wolffian duct can be recognized (fig. 13, w.d.).

The two canals open together into the dorso-lateral wall of the urogenital sinus. The ventrally placed urethra opens into the sinus at the same level.

Urogenital sinus (u.g.s.)

As was mentioned earlier, the urogenital sinus follows the general dasyure plan in that it is much longer than the antero-posterior measurement of the vaginal complex. This is clearly shown in fig. 3 and in Table 1.

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a.v.c.—Anterior vaginal canal
bl.—Bladder
cl.—Clitoris
lev. ur. p.—Level of the ureteric papillae (1)
l.v.—Lateral vagina
M.d.—Müllerian duct
m.v.c.—Median vaginal cul-de-sac
m.v.n.—Median vaginal neck
occ.M.d.—Occluded Müllerian duct
occ.W.d.—Occluded Wolffian duct
os. ut.—Os uteri
r.ur.—Right ureter
sept.—Septum between r. & l. culs-de-sac
s.h.—sinus horn
u.g.s.—Urogenital sinus
ur.—Ureter
ureth.—Opening of the Urethra into the urogenital sinus
ut.—Uterus
ut.n.—Uterine neck
ut.p.—Uterine papillae
W.d.—Wolffian duct

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(1) Also shown by the posterior pair of crosses in Fig. 7 and by the single pair of crosses in Figs. 10 and 13.

Explanation of Figures [1]

Fig. 1.—Dorsal view of the female urogenital system of *Dasyurus*, No. 88 x ¾.

Fig. 2.—Dorsal view of the urogenital system of *Sarcophilus* (No. 50) x 1.

Fig. 3.—Dorsal view of the urogenital system of *Thylacinus* (No. 199) x 3.

Fig. 4.—Dorsal view of the urogenital system of *Antechinus* (No. 291) x 5.

Fig. 5.—*Dasyurus*, No. 88 x 5. Vertical paramedial section through the vaginal region. (The uterine neck, urethra and urogenital sinus are only partly shown).

Fig. 6.—*Dasyurus*, No. 88 x 5. Horizontal section showing the uterine necks opening into the right and left culs-de-sac.

Fig. 7.—*Dasyurus*, No. 88 x 5. Horizontal section through the same region. The positions of the ora uterorum are indicated by the two small crosses and those of the openings of the two ureters into the bladder by the two larger crosses.

Note.—If a tracing of fig. 6 is made on transparent paper and applied to the appropriate part of fig. 7, the relative positions of the uterine necks and the anterior vaginal canals will be more readily understood. A, B, C and D mark the levels of the four transverse sections illustrated in fig. 8.

Fig. 8.—*Dasyurus*, No. 88 x 5. Four transverse sections, A, B, C and D taken through the four levels indicated in figs. 5 and 7.

Fig. A.—T.S. through the region of the uterine necks and the anterior vaginal canal.

Fig. B.—T.S. through the region of the culs-de-sac.

Fig. C.—T.S. taken at the level of the openings of the ureters into the neck of the bladder. The urethra may be regarded as starting at this point.

Fig. D.—T.S. taken slightly anterior to the opening of the lateral vaginae with the urogenital sinus.

Fig. 9.—*Sarcophilus*, No. 50 x 9. Vertical paramedial section through the vaginal region. (The uterine neck, urethra and urogenital sinus are only partly shown).

Fig. 10.—*Sarcophilus*, No. 50 x 9. Horizontal section through the same region as in fig. 9. The two crosses indicate the position of the openings of the ureters into the neck of the bladder.

A, B, C, D, E, F and G indicate the respective levels at which the transverse sections, shown in fig. 11, are cut.

Fig. 11.—*Sarcophilus*, No. 50 x 9. Seven transverse sections taken through the seven levels A-G indicated in figs. 9 and 10.

Fig. A.—T.S. through the region of the ora uterorum.

Fig. B.—T.S. showing the right and left median vaginal necks (*m.v.n.*) and the anterior extremities of the anterior vaginal canals (*a.v.c.*).

Fig. C.—T.S. showing the connexions between the median vaginal necks and the main body of the cul-de-sac.

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[1] In figs. 1-7, 9, 10, 12 and 13 the urinary bladder and urethra are not shown. However the level at which the ureters enter the neck of the bladder (*lev.ur.p.*) and the opening of the caudal end of the urethra with the urogenital sinus (*ureth.*) are indicated.

FIG. D.—Transverse section showing the confluence of the cul-de-sac and the anterior vaginal canal (*a.v.c.*).

FIG. E.—Transverse section showing the connexion between the anterior vaginal canal and the lateral vagina (*l.v.*).

FIG. F.—Transverse section through the level at which the ureters (*ur.*) open into the neck of the bladder (anterior extremity of the urethra, *ureth.*).

FIG. G.—Transverse section through the occluded portion of the lateral vagina, showing the vestige of the Wolffian duct (*occ. W.d.*) at the level at which it joins the Müllerian duct (*occ. M.d.*).

FIG. 12.—Lateral view of the female urogenital system of *Thylacinus* juv. x 20.

FIG. 13.—Dorsal view of the female urogenital system of *Thylacinus* juv. x 20.

FIG. 14.—*Thylacinus* juv. x 20.

A.—T.S. through A in fig. 13.

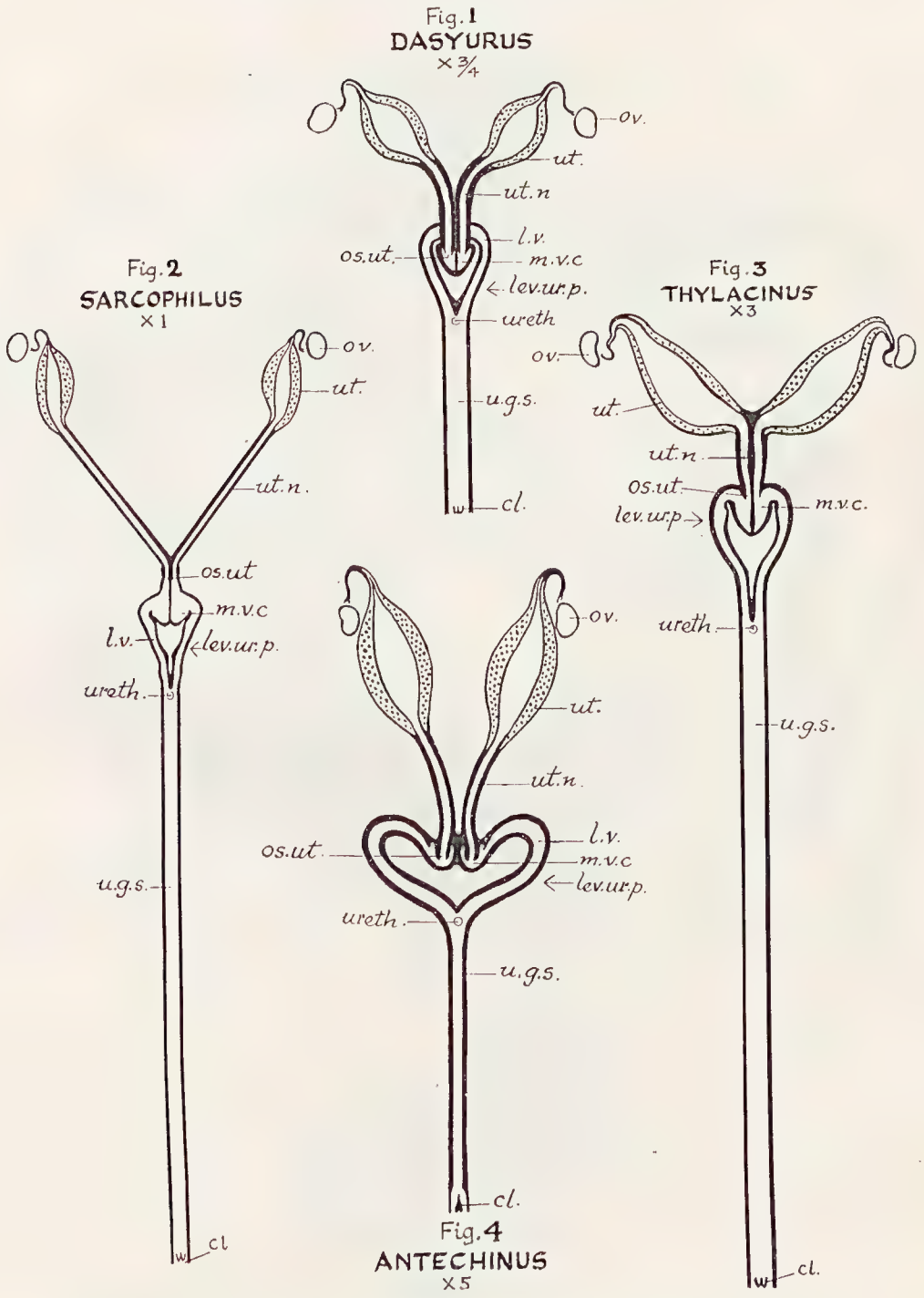
B.—T.S. through B in fig. 13.

C.—T.S. through C in fig. 13.

D.—T.S. through D in fig. 13.

E.—T.S. through E in fig. 13.

NOTE.—*l.v.* in fig. E should more correctly be termed sinus horn. The two sinus horns constitute the caudal sections of the lateral vaginae (*l.v.*) and are antero-dorsal outgrowths of the urogenital sinus.



FIGS. 1-4.—Horizontal sections of *Dasyurus*, *Sarcophilus*, *Thylacinus* (juv.) and *Antechinus* respectively.

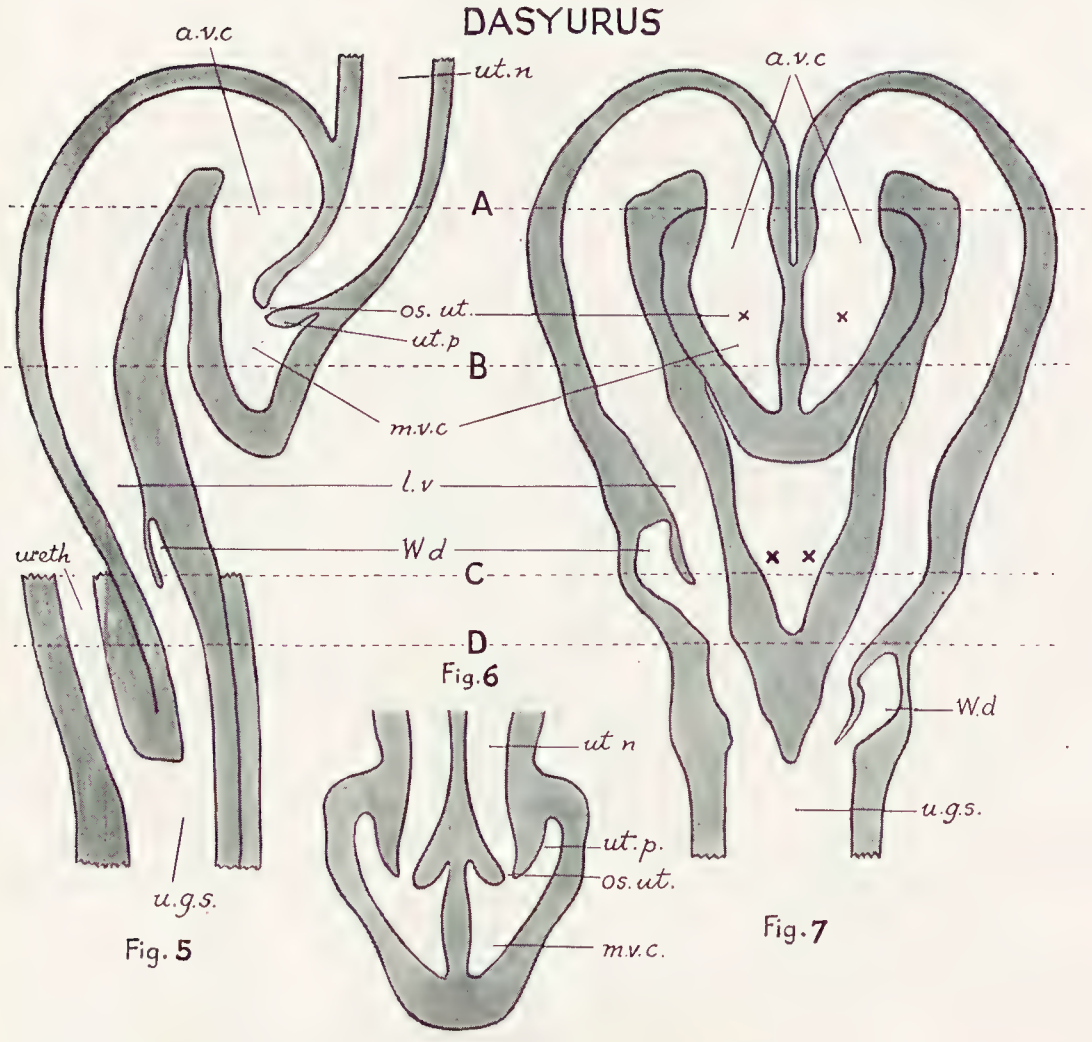


FIG. 5.—Paramedial section through vaginal region (*Dasyurus*) x 5.

FIG. 6.—Horizontal section showing connexions between the uterine necks and the culs-de-sac (*Dasyurus*) x 5.

FIG. 7.—Horizontal section of vaginal region (*Dasyurus*) x 5.

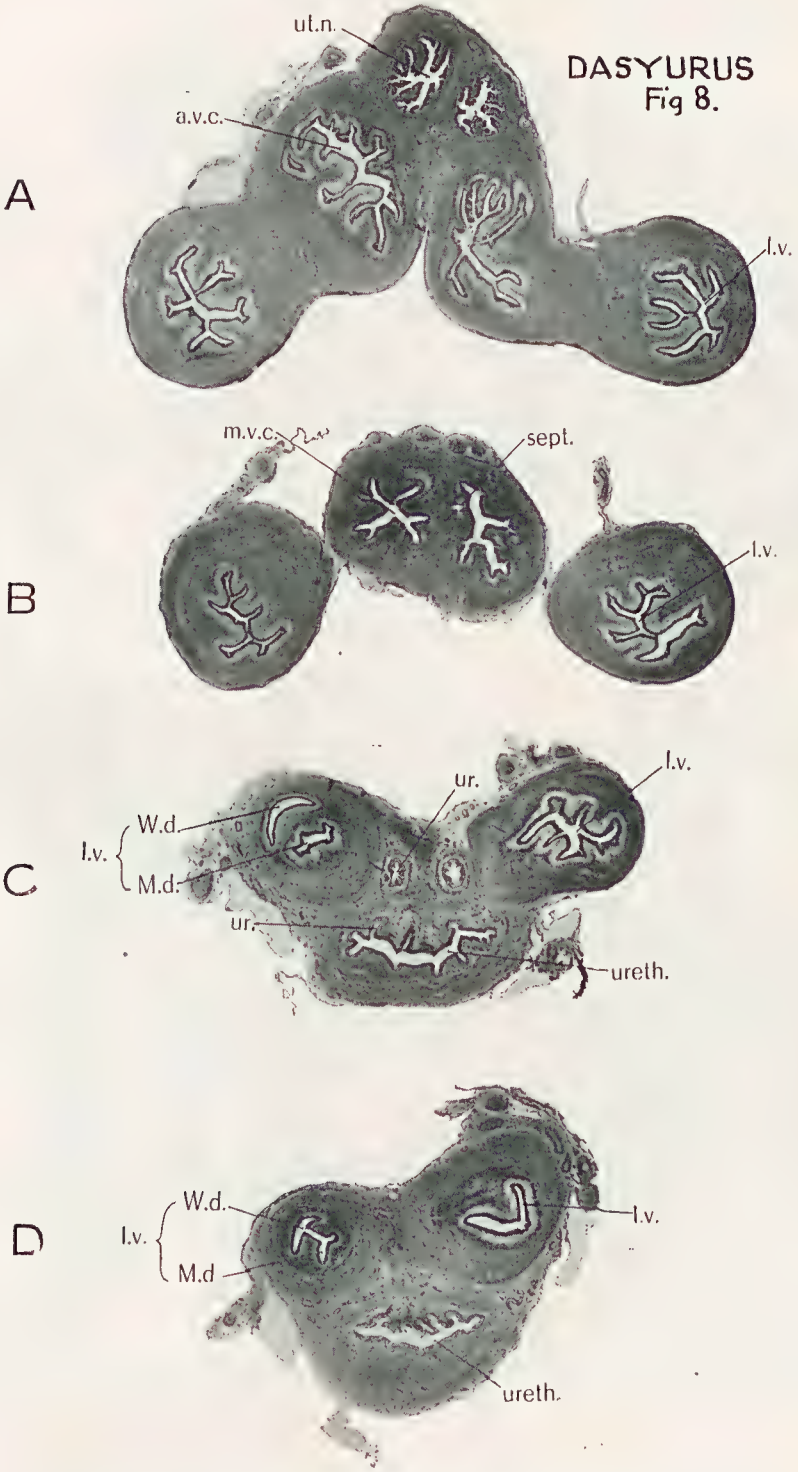


FIG. 8.—Four transverse sections through figs. 5 and 7 (*Dasyurus*) x 5.

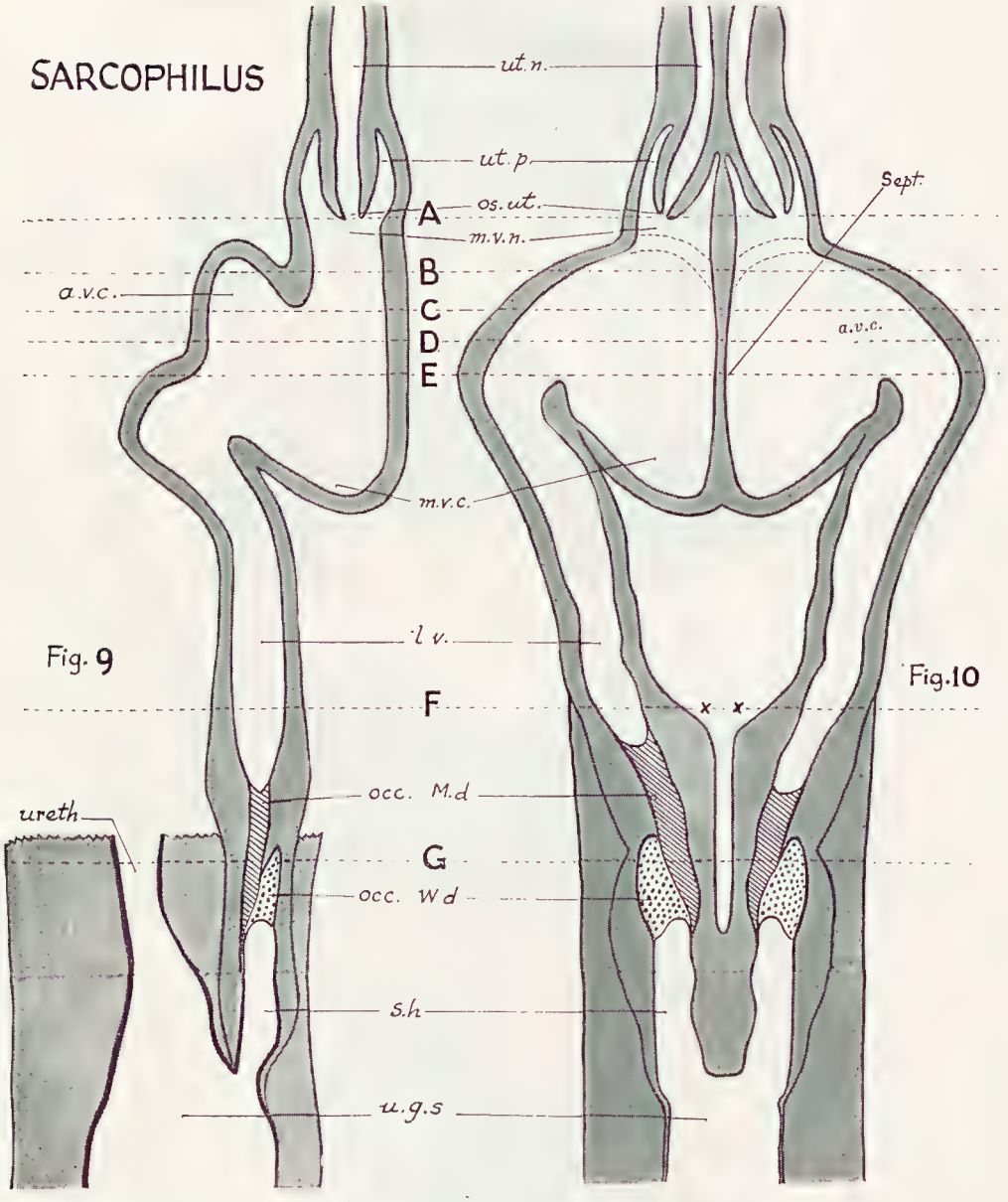


FIG. 9.—Paramedial section through vaginal region (Sarcophilus) x 9.
FIG. 10.—Horizontal section through same region as in fig. 9. (Sarcophilus) x 9.

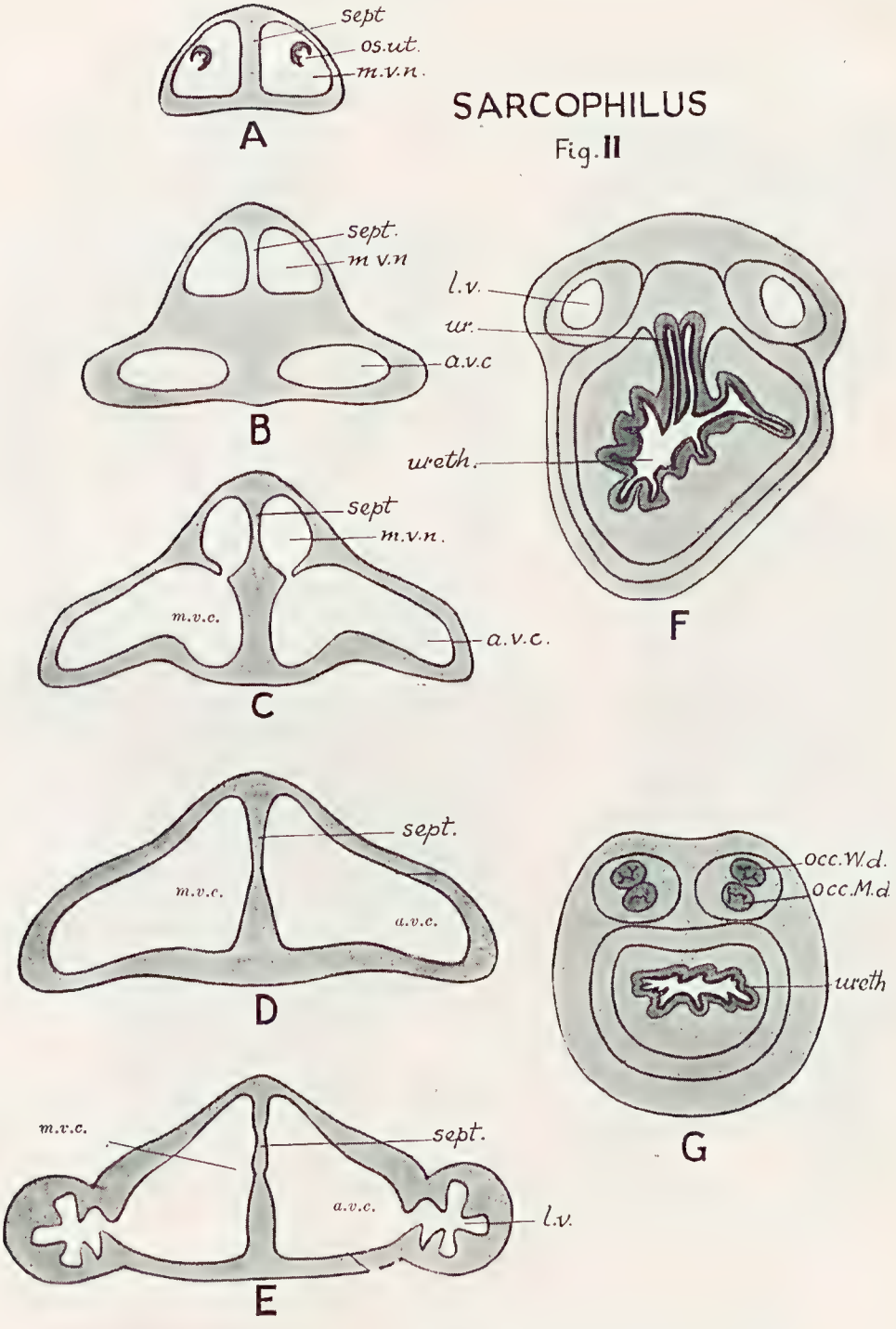


FIG. 11.—Transverse sections through fig. 10. (Sarcophilus) x 9.

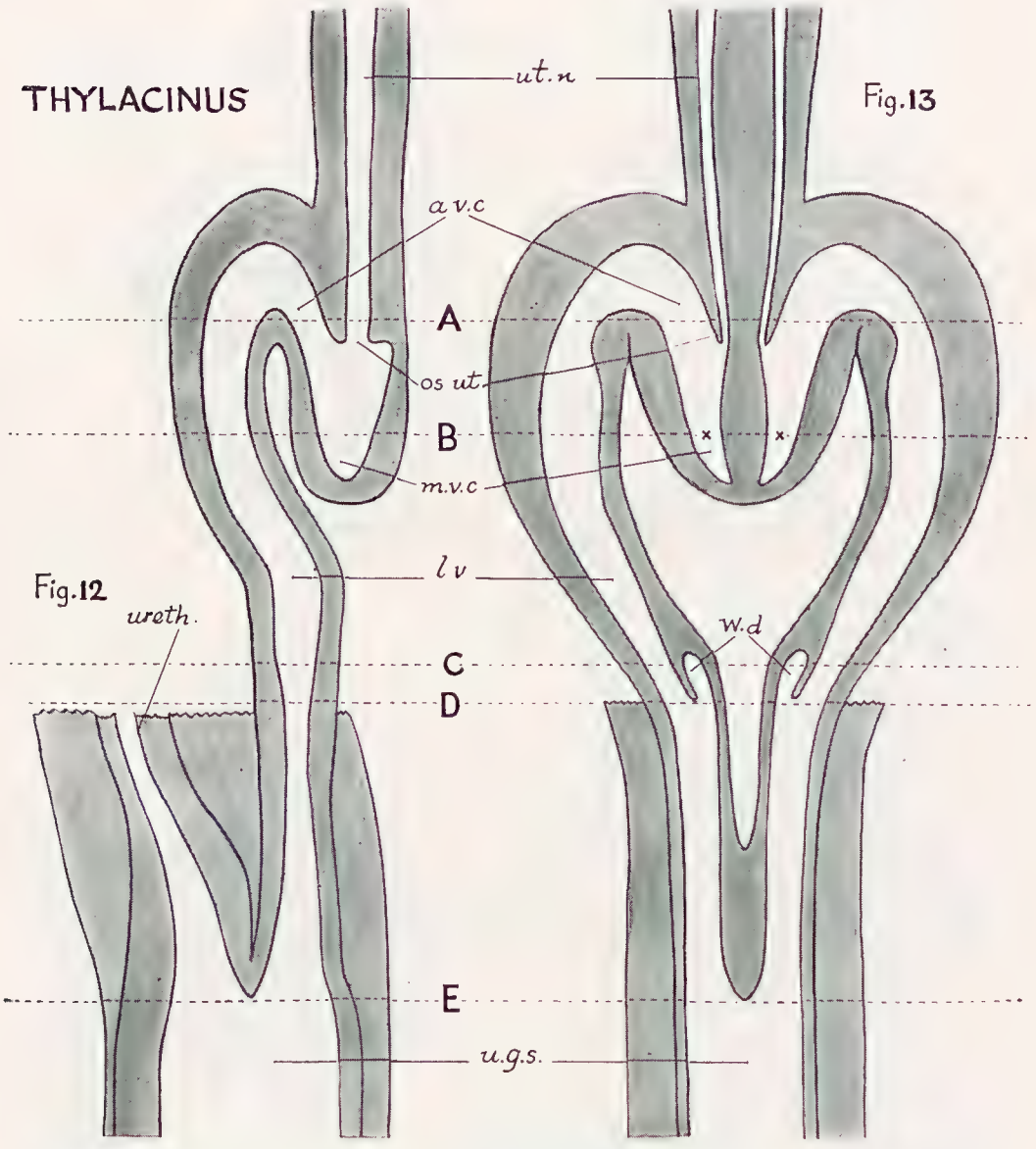


Fig. 12.—Paramedial section through the vaginal region (*Thylacinus* juv.) x 15.
Fig. 13.—Horizontal section through the same region as fig. 12. (*Thylacinus* juv.) x 15.

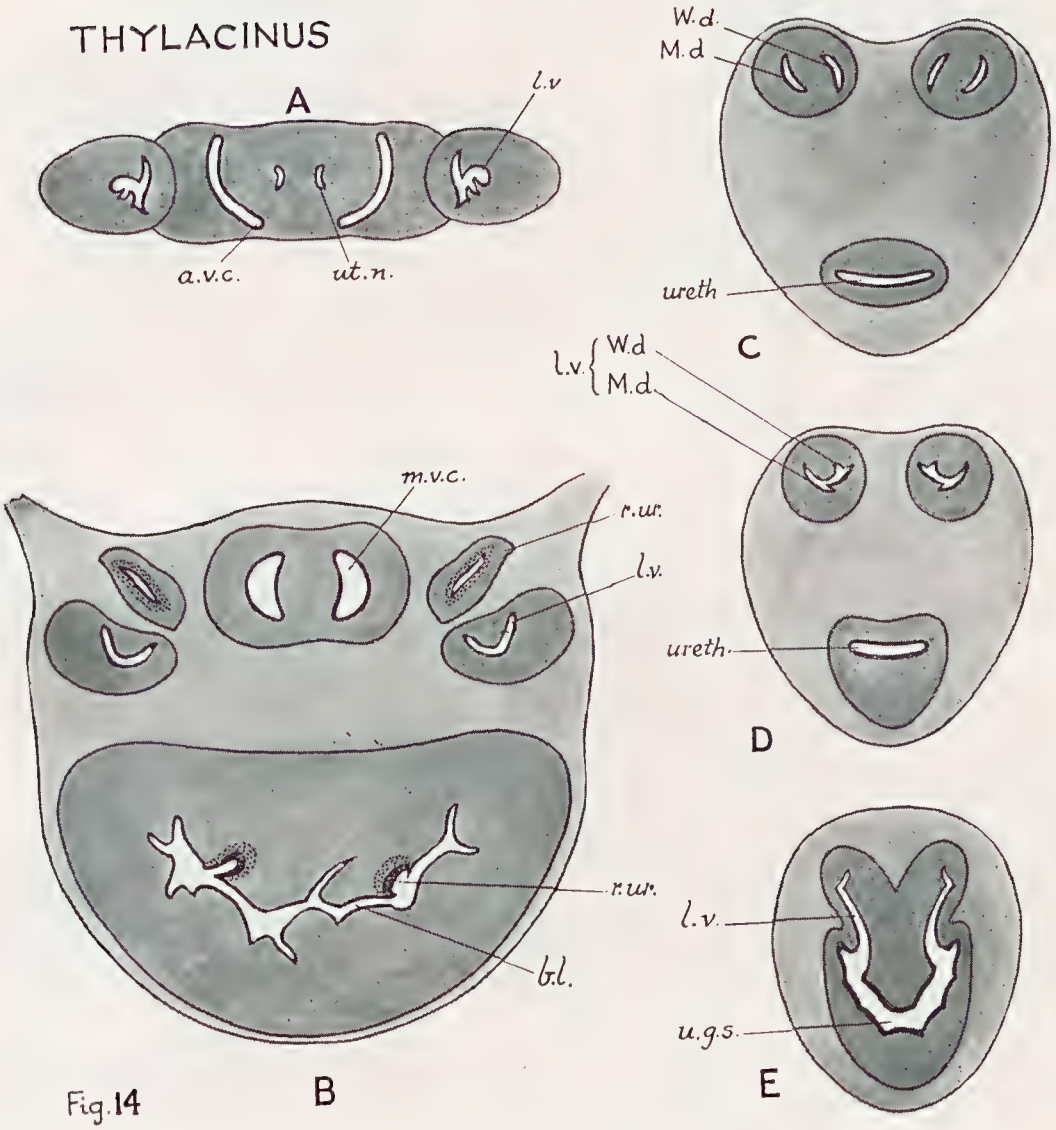


FIG. 14.—Transverse sections through figs. 12 and 13. (*Thylacinus* juv.) x 15.

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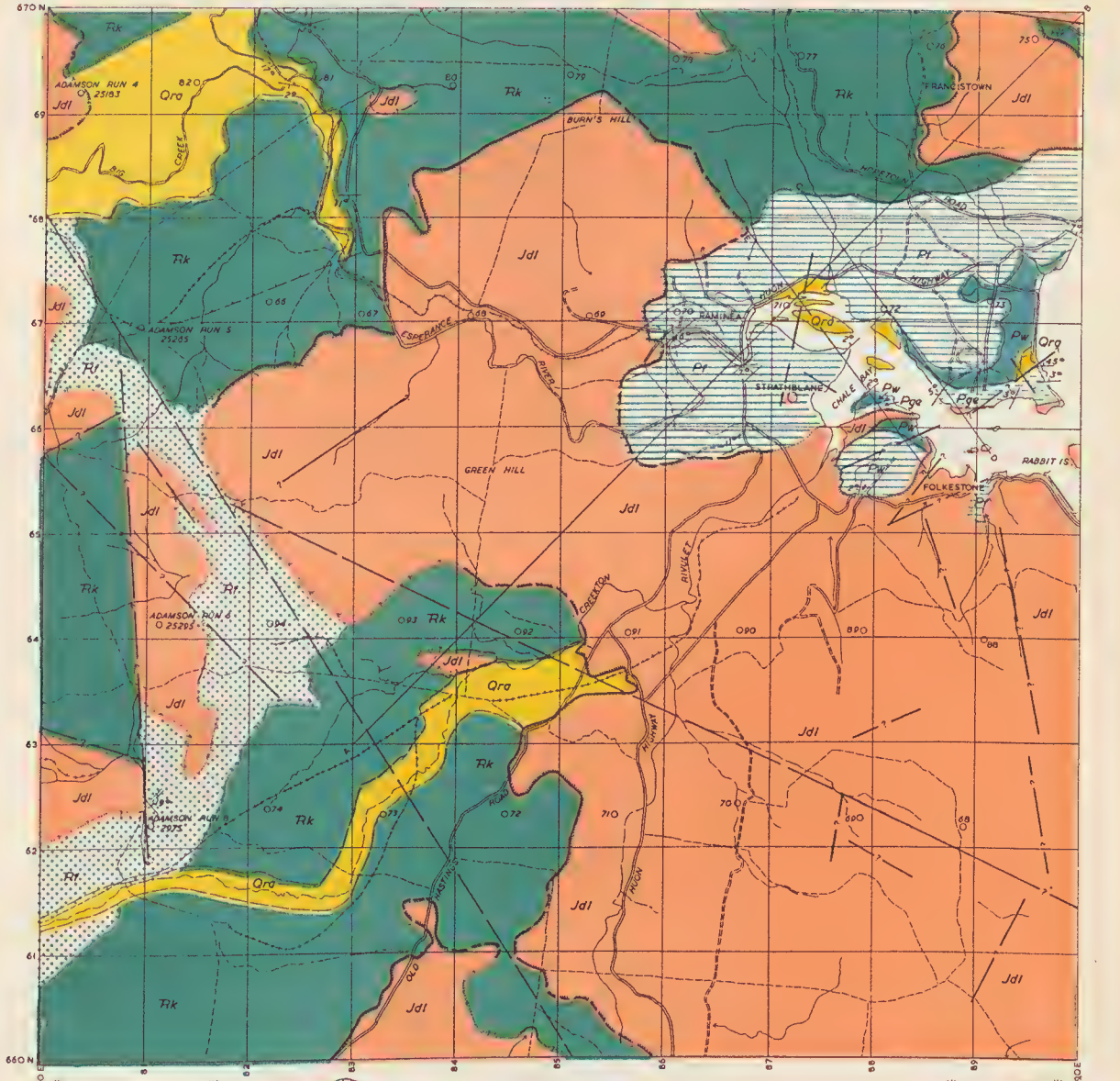

— FAULT WITH DOWNTHROW SIDE INDICATED

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FORMATION BOUNDARY

BOUNDARY CONCEALED

DOLERITE BOUNDARIES

CONCORDANT SILL

DISCORDANT INTRUSIVE BOUNDARIES

DISCORDANT INTRUSIVE BOUNDARIES WITH CONCOMITANT FAULTING

JOINTS

STRIKE AND DIP

ROADS

VEHICULAR TRACK

TRACK

DISUSED TRAMWAY

TELEPHONE LINE

— SCALE —

0 2 MILES

0 1 2 3 4 5,000 10,000

KEY MAP SHOWING MAGNETIC VARIATIONS

9·5° E

10° E

10·5° E

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Quaternary System

RECENT SERIES

Qra ALLUVIUM

Triassic System

FELSPATHIC SANDSTONE

KNOCKLOFTY SANDSTONE AND SHALE

Permian System

Pf FERNTREE MUDSTONE

Pw WOODBRIDGE GLACIAL FORMATION

Pgg GRANGE MUDSTONE

Jurassic System

Jdl DOLERITE

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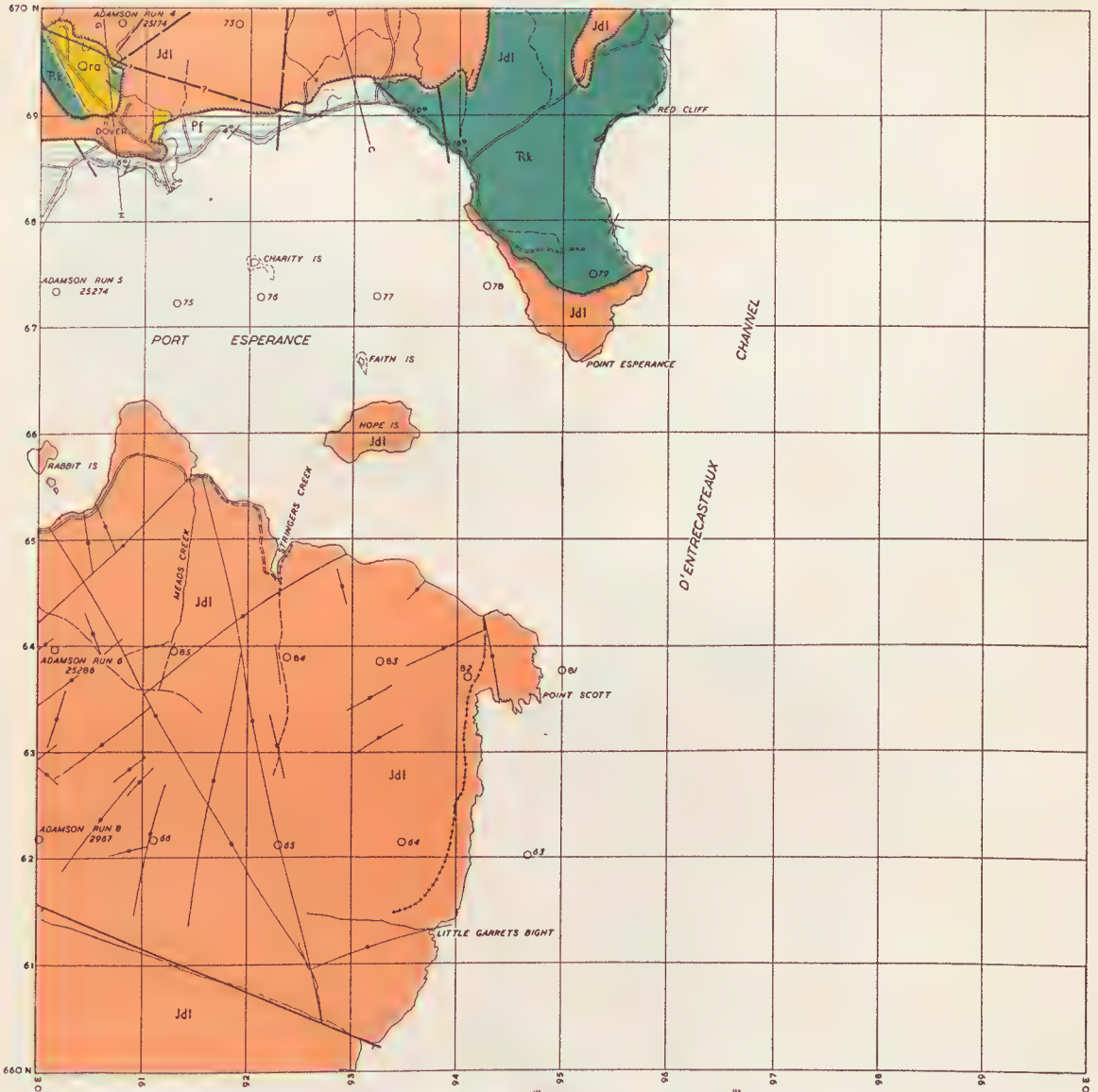
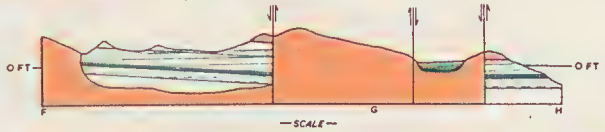


For section line F-G and section B-C see Police Point, map square 49-67.



— SCALE —

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- FAULT WITH DOWNTHROW SIDE INDICATED
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- FAULT INFERRED
- FORMATION BOUNDARY

DOLERITE BOUNDARIES

- CONCORDANT SILL
- DISCORDANT INTRUSIVE BOUNDARIES
- DISCORDANT INTRUSIVE BOUNDARIES WITH CONCOMITANT FAULTING
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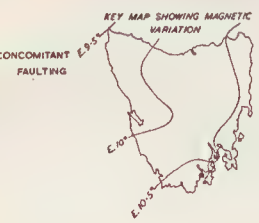

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Jurassic System
- Jdl DOLERITE

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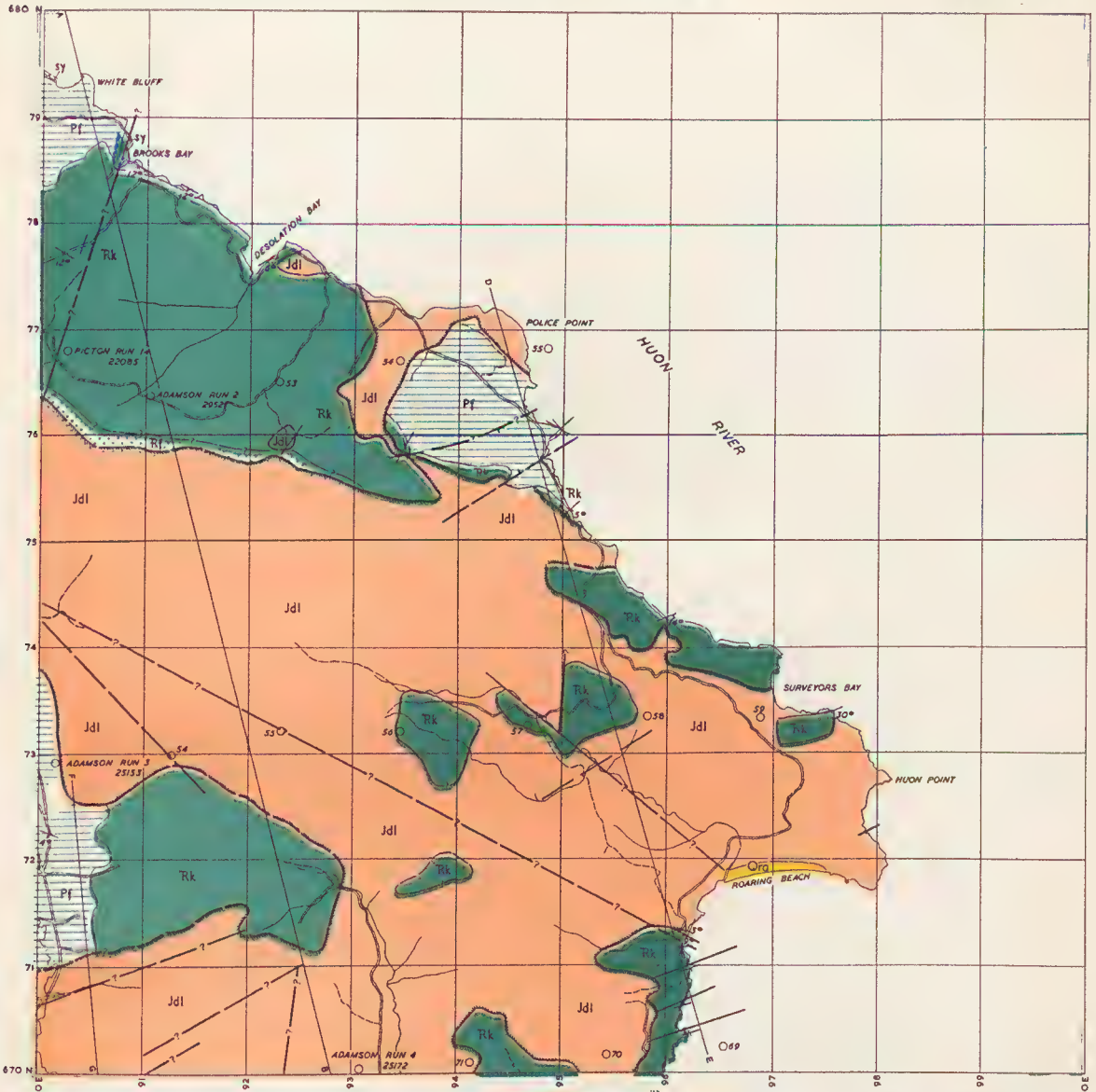

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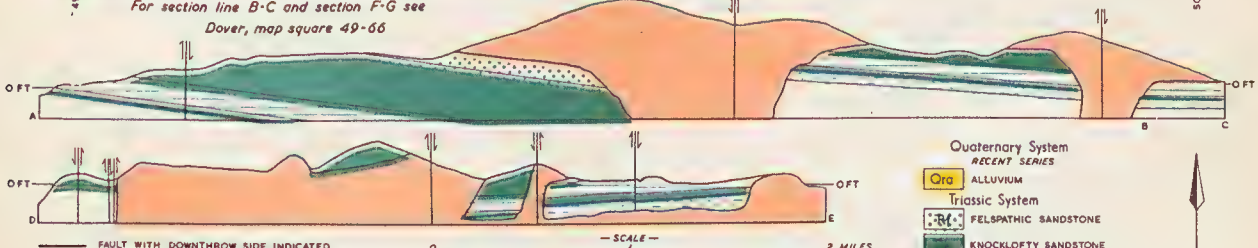

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STRIKE AND DIP
ROADS
VEHICULAR TRACK
TRACK

— SCALE —

0 1 2 3 4 2 MILES

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Pw WOODBRIDGE GLACIAL FORMATION
Pge GRANGE MUDSTONE
Jurassic System
Jdl DOLERITE
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